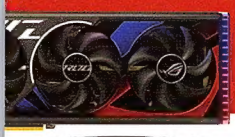

RTX 4090: SIMPLY ASTONISHING

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HINT: AMD SHOULD WORRY

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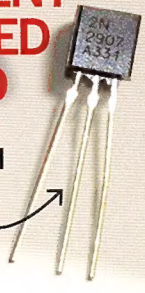
THE COMPONENT THAT CHANGED THE WORLD

AND YOU OWN *BILLIONS* OF THEM



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IS IT INTEL?

9-13900K & i5-13600K IN THE LABS

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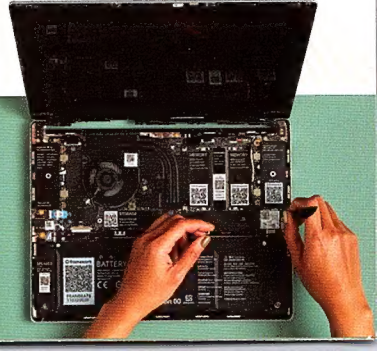

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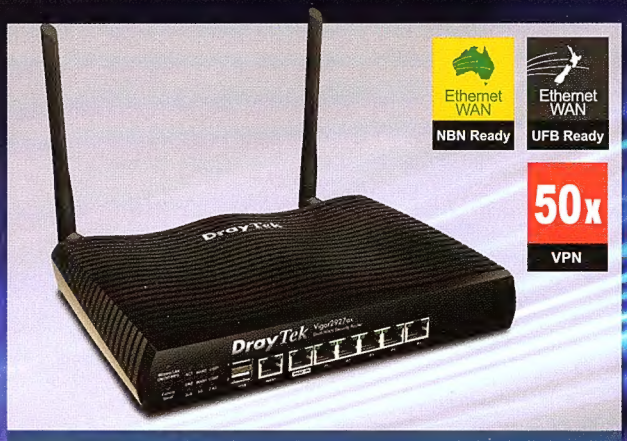

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EDITORIAL

WHAT'S INSIDE *APC*

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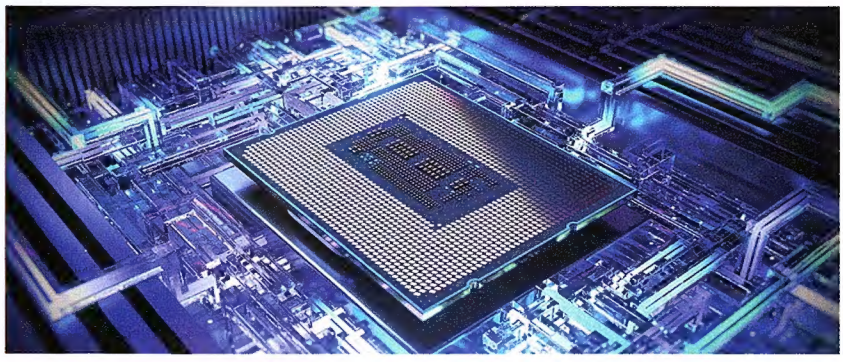


EDITORIAL

A mighty year

Ends with a bang

BEN MANSILL likes numbers that go up. Except when they're prices.

Well, it's decision time – if you were holding out to hear about whether Intel's 13th Gen should be your next upgrade, that is. Last month was AMD's moment in the spotlight, and now the Labs have been churning through the 13900K and 13600K and generating numbers, and more importantly – opinions in Chris' opinionated head.

I just love this game. Even if you're not on the cusp of upgrading it's so fascinating to watch on as the battle rages, and new capabilities and performance becomes real. We'll certainly be looking closely at other chips in the new Ryzen 7000 and 13th Gen families in upcoming issues of APC.

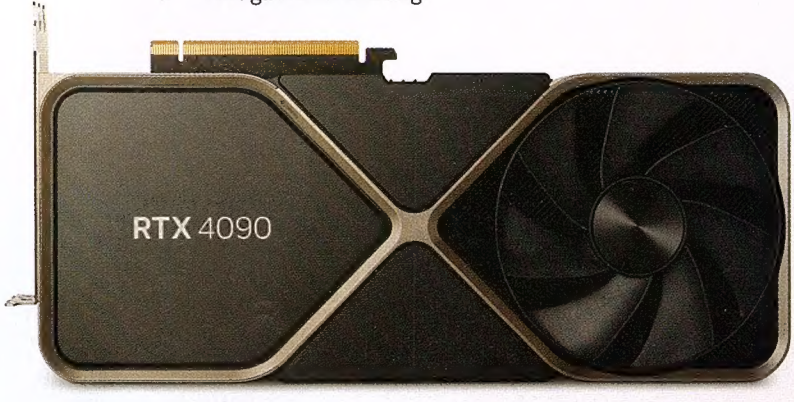
And then there's the Nvidia RTX 4090. Holy smokes, this thing. Never have we seen such a massive generational uplift, it's truly astonishing. This beast is a monster for raw rasterisation performance, and on top of that pure brute force power, it ushers in the miracle that is DLSS 3. This is the real deal, not a 'take it with a grain of salt' feature. Frame generation can double your FPS or more. It's beyond belief – except it's real. Unlike previous new techs that need dev support – and only saw lukewarm take-up, we expect game devs to rapidly embrace DLSS 3 and quickly add support for new and many existing games.

> "And then there's the Nvidia RTX 4090. Holy smokes, this thing. Never have we seen such a massive generational uplift, it's truly astonishing."

Of course, if nobody buys a 4090 then it's all for nought, and if the next 12 months means a market flooded with bargain-priced 3000 series cards, DLSS 3 support may slow a little. But it'll get there, it's too good to be ignored. And yes, these things are ridiculously expensive. There's no getting away from that. Almost $4k for a graphics card... crikey.

As we close this issue the new AMD Radeon RDNA 3 cards will be coming in the door, so perhaps AMD can do some pricing magic that will force some sanity into Nvidia's strategy. Come on Red, save us again. Please. And this time deliver performance that evens up the contest, and maybe has some trickery that is as impressive as DLSS 3.

This game! So exciting.



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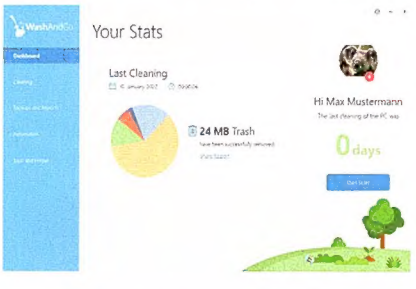

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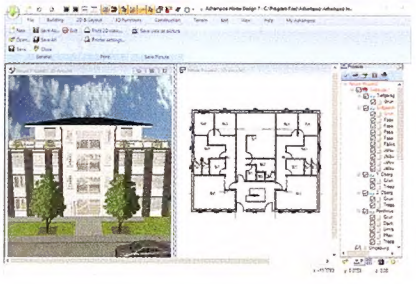

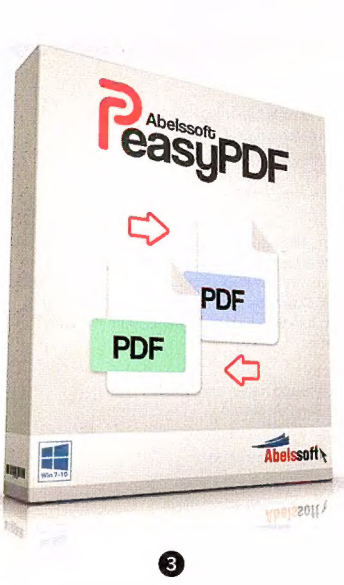

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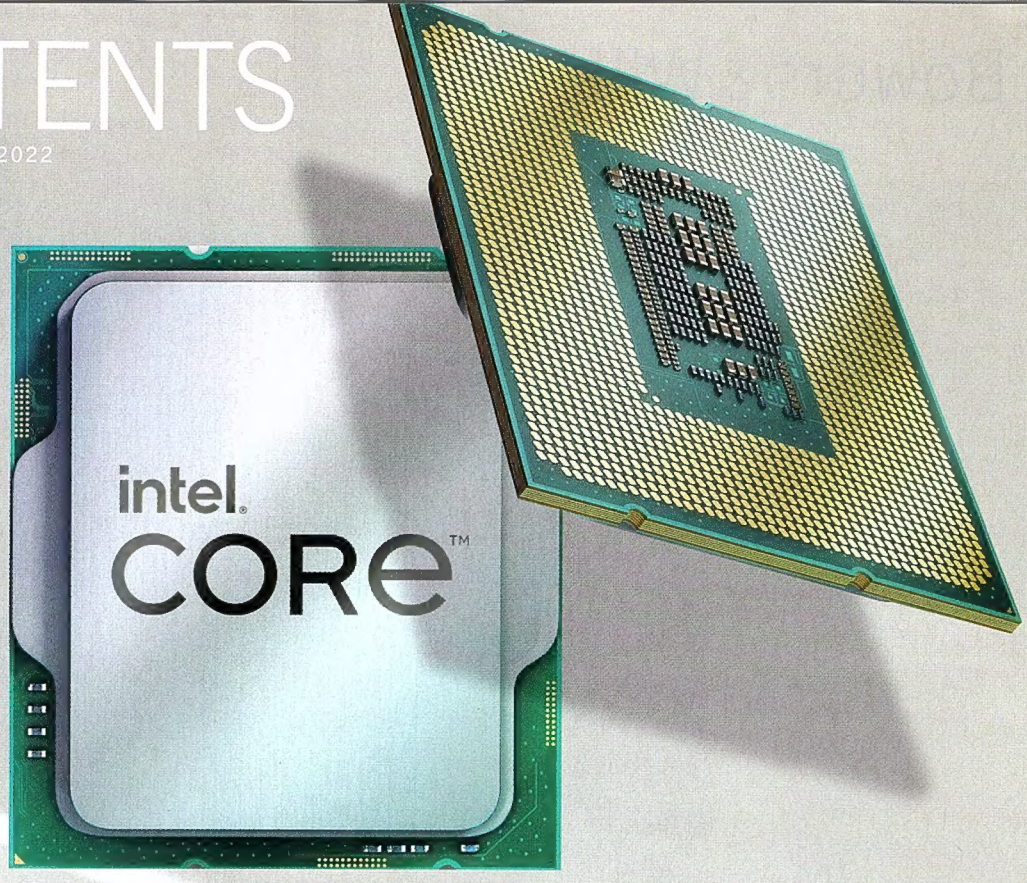

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Don't pay for expensive new components to improve the performance of your PC.

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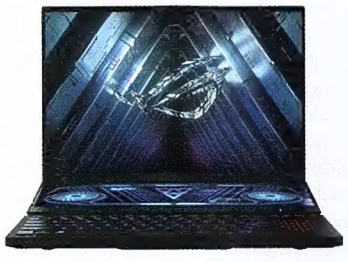

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HOW WE DO IT

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PLUS THE NEW Z790 BOARDS TESTED & EXPLAINED

"Championing technology doesn't mean we're unrelenting yes-men and -women, however, and *APC* aims to be as objective as possible in all our coverage."

APC is Australia's oldest consumer technology magazine – having been consistently in print for forty years, since our first issue way back in May 1980 – and we take that heritage and responsibility very seriously. While our focus is obviously on the personal computer the very definition of the PC has changed and shifted markedly since the early 1980s. As such, we touch on many other areas of tech, too, from smartphones and apps to peripherals, accessories, and beyond. We have two goals: to find the best modern tech and to help you make the most of it.

We're also an open church in terms of platforms. We know most people aren't wed to a single brand's products and use a variety of devices. And, like you, *APC*'s journalists want to know what's good in tech – no matter what platform it resides on.

Independent reviews

Championing technology doesn't mean we're unrelenting yes-men and -women, however, and *APC* aims to be as objective as possible in all our coverage. That means identifying the best products from multiple perspectives – the best performance, best value and best features and, ideally, the products that offer the best mix of these three attributes.

As a matter of policy, reviews published in *APC* are not shared with product-makers prior to print. We will contact vendors under certain conditions; for example, if we have a problem testing a product that seems to indicate it may be faulty, or to invite a vendor to clarify how a particular feature works. If an *APC* reviewer has any potential conflicts of interest involving a brand, the review will always be assigned to another writer.

Labs testing

APC strives to conduct the most rigorous, objective scientific tests and benchmarks we can so as to make our reviews as unbiased as possible. We use a variety of tools and programs for this, including many freely available benchmark suites for assessing media encoding, general system performance including storage read and write speeds, gaming and battery life.

In most cases, for the benchmark results published in *APC*, you can assume that higher is better. There are certain tests that deviate from this rule where the opposite is true; in those cases, we've flagged the results with a note explaining as such.

We use both tables and graphs for displaying results; the latter offers better ease-of-readability, but tables are more compact, so we use these in most cases where thoroughness is preferred.

UPDATED FOR 2023

apc TESTBED

The current APC testbed used in the Labs for benchmarking all components. This testbed is updated as new and relevant technology comes on stream.

CPU	Intel Core i9 12900K
Motherboard	Asus Maximus Z690 Apex
Graphics Card	Nvidia GeForce RTX 4090 Founders Edition
RAM	2x16GB G.Skill Trident Z5 DDR5-6000
Power Supply	Corsair AX1000
Storage	Seagate Firecuda 530 2TB
Case	Thermaltake Core P8
Cooling	Cooler Master Flux PL360 AIO
Operating system	Windows 11 Pro 22H2

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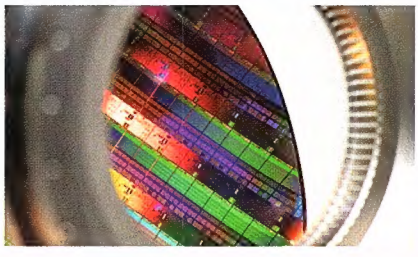
G.SKILL ACHIEVES DDR5-10000 ON AIR COOLING

G.Skill says it has touched a milestone: DDR5-10000 on air cooling. This satisfyingly round-numbered feat was achieved using a single air-cooled Trident Z5 memory module and some hardware and technical help from Asus. The headlining DDR5-10000 achievement by G.Skill was achieved using only air cooling used for both the system processor and RAM. While numerically impressive, the overclocked DDR5 won't be part of any practical PC build, as it needed to run with a single memory module for the system to be stable enough to validate the performance using CPU-Z. G.Skill also showcased DDR5-8000 CL40 32GB and DDR5-7800 CL38 32GB memory kits validated on an Intel Core i9-13900K processor and Asus ROG Maximus Z790 Apex motherboard (BIOS 0702) platform.



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JAPAN GOES ALL-IN FOR 2NM

A new $3.8 billion research hub comprised of Japanese and American semiconductor companies that are yet to be named, as well as multiple universities from Japan, the U.S. and Europe. Among the Japanese universities, the business publication *Nikkei* names the University of Tokyo, the National Institute of Advanced Industrial Science and Technology, and Riken. IBM is also said to be among the candidates to participate. The hub will conduct fundamental research to explore materials needed to make chips using a 2nm-class fabrication technology by the latter half of the decade. But it's is unclear whether Japan has plans to build actual fabs that will make commercial chips. And if such plans exist it is unclear which of the Japanese companies have enough money and scale to make chips on a leading-edge node.

GPU

AMD announces RX 7900 XTX & RX 7900 XT

RDNA 3 is bringing performance per watt and performance per dollar.

AMD has finally unveiled its next-generation GPU architecture, RDNA 3, and the first two cards to be built using the architecture: the Radeon RX 7900 XTX and the Radeon RX 7900 XT. Both cards will be available to purchase on December 13, 2022.

We've been waiting a long time for details on these two cards, so let's not dally around. AMD's bringing some impressive specs to bear with its two brand new enthusiast-grade cards, and the RX 7900 XTX is promising to deliver up to 61 TFLOPs of compute performance – nearly three times the 23 TFLOPs from the RX 6950 XT.

The RX 7900 XTX will employ the power of 96 RDNA 3 Compute Units (CUs), tantalisingly close to a triple-digit count. It will operate at a game clock of 2.3GHz, and comes with a generous helping of VRAM with 24GB of GDDR6 total. As the top card announced by AMD today, this comes with a 335W total board power (TBP). That's the same TBP as the RX 6960 XT yet the RX 7900 XTX is promising to be up to 67 percent faster than the card it replaces at the top of the stack.

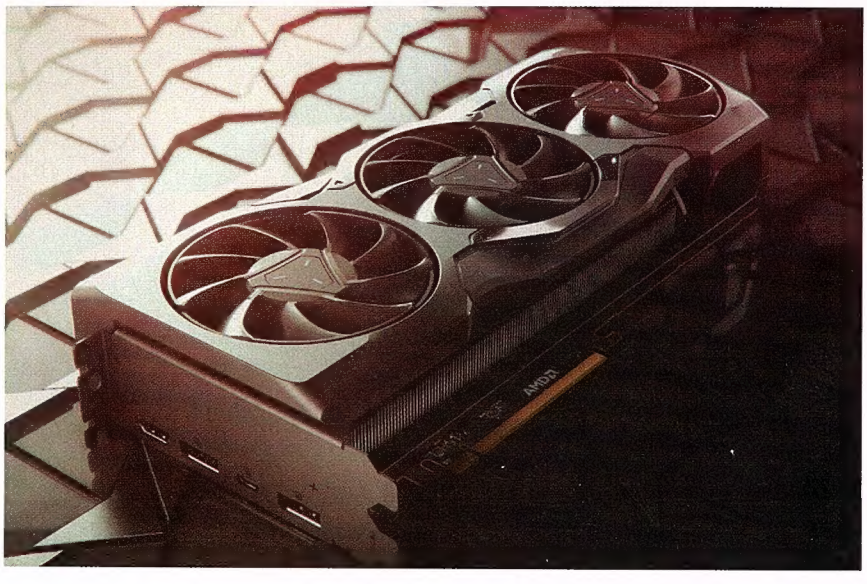
"AMD's bringing some impressive specs to bear with its two brand new enthusiast-grade cards, and the RX 7900 XTX is promising to deliver up to 61 TFLOPs of compute performance – nearly three times the 23 TFLOPs from the RX 6950 XT."

Then there's the RX 7900 XT. This comes with 12 fewer CUs than the XTX model, for a total of 84 CUs. It's up there in terms of clock speed, though, at 2GHz game clock, and comes with 20GB of GDDR6. It runs at a slightly more modest 300W TBP.

Both cards will stick with two 8-pin power connectors to deliver the wattage required to run them, though AMD hasn't precluded its partners adding another 8-pin for extra oomph with overclocked cards.

DisplayPort 2.1 will also be supported via AMD's new Radiance Display engine, which will allow for frame rates up to 480Hz at 4K and 165Hz at 8K. Whether you can actually make the most of that is another thing entirely, but it's good to see AMD include the display connector when Nvidia notably did not on the RTX 4090.

Australian pricing hadn't been announced at the time we went to press, but as a yardstick US pricing is US$999 for the RX 7900 and US$899 for the 7900 XT, which is close to half the price of Nvidia's new 4000 series cards. We're hoping to have a full review in the next issue!



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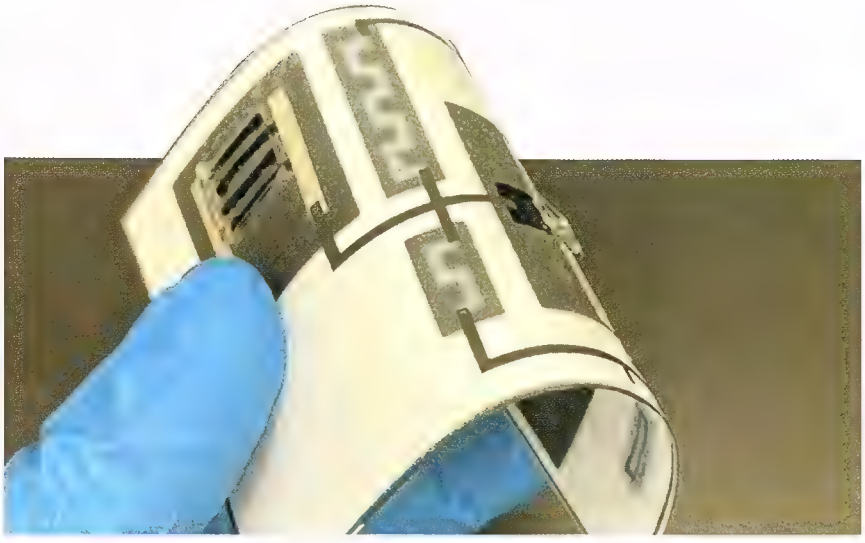

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Paper PCBs the future of disposable electronics?

Definitely not suitable for 600W video cards.

Electronics has a big waste problem, often referred to as eWaste. However, a recent study into Integrated Papertronic Techniques may provide a path away from the toxic eWaste dystopia. The study looks closely at the potential of using paper in disposable electronics, beginning with paper-printed circuit boards (PCBs). Futurist Faisal Khan reckons the study, published by researchers from the State University of New York at Binghamton, shows single-use paper PCBs are the future of disposable electronics.

Paper is a highly affordable, accessible, flexible, and sustainable material, which is thus a strong candidate for environmentally friendly PCB designs. Current PCBs are made of an environmentally unfriendly blend of glass fibres, resins and metal wiring. In the drive to combat eWaste we must consider how to both increase recycling rates of electronic devices and produce more single-use electronics using appropriate biodegradable materials.

it is envisioned that disposable paper PCBs will be used in wireless sensor networks and the Internet of Disposable Things (IoDT). It should be noted that paper PCB-based devices will need additional packaging care, due to their susceptibility to humidity impacting active use- and shelf-life.

© Samsung

THE FIRST DISPLAYPORT 2.1 8K ULTRAWIDE MONITOR

Shame it isn't really 8K.

AMD's Radeon 7900 cards support DisplayPort 2.1, the new connection standard that supports higher refresh rates at high resolutions. The AMD launch also offered up a sneaky peek at Samsung's first 8K ultrawide monitor, the Odyssey Neo G9.

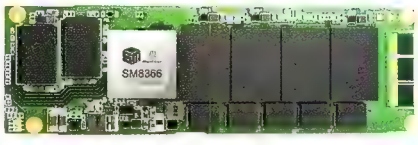
The only problem with this particular screen is that it isn't really an 8K panel, due to its ultrawide configuration. For reference, 8K should officially be 7680x4320, which equates to a frankly staggering 33.2M pixels. For comparison, 4K is 3840x2160 for a total of 8.3M pixels. The footnote on the presentation pointed out though, the Samsung screen offers 8K horizontal only. Given the existing Odyssey Neo G9 has a 32:9 aspect ratio, that would lead to a native resolution of 7680x2160 for a total of 16.6M pixels or roughly half the full resolution of a true 8K display.

© Future

PHILIPS ANNOUNCES NEW EVNIA GAMING BRAND

Coming in three distinct tiers, the 5000, 7000, and 8000 series, Evnia will soon bring us matching gaming monitors, mice, and keyboards. At the top end comes a vast, 42-inch, flat-screen OLED gaming monitor, the catchily titled 42M2N8900, which will come in at 138Hz with a 0.1ms response and HDMI 2.1. We'll also see a 34-inch, curved OLED, a UHD gaming monitor with a 21:9 aspect ratio. A curved 32-inch, UltraWide monitor will also be coming with a native 3440x1440 resolution, 165Hz refresh, DisplayHDR 1400 support.

Alongside the monitors announced, we'll be getting keyboards (sporting Cherry MX switches), two all new gaming mice, and two gaming headsets so you can get a full Evnia setup going.



SILICON MOTION DEMOS PCIE 5.0 SSD @ 13.6 GBPS

Silicon Motion has demonstrated working solid-state drives based on its first platform for SSDs featuring a PCIe 5.0 interface. The SM8366-based drives used different types of memory from other manufacturers, which indicates that SMI is working with all makers of 3D NAND to provide maximum flexibility to its partners.

The demo drive that SMI showcased at the Open Compute Project (OCP) forum offered a sequential read performance of 13.6 GBps and a random read performance of 3.4 million IOPS, according to Storage Review. Regarding sequential speed, SMI's SM8366-based drive was a little slower than Samsung's PM1743 SSD (which offers up to 13.8 GBps) but was a bit ahead of Phison's PS5026-E26-based drive (that offers up to 12.4 GBps when equipped with a good memory). ■

TECH BRIEF

DisplayPort 2.1 brings the bandwidth

Touts improved coexistence of data and video signals over USB4 connections.

VESA released version 2.1 of the DisplayPort specification in mid October. The update brings several important changes concerning efficiency, but as you will read, VESA strove to keep things smooth for both implementers and consumers.

DisplayPort 2.1 is more than just backward compatible with DisplayPort 2.0. Due to the efforts of VESA and its partners, "all previously certified DisplayPort 2.0 products... have already been certified to the stricter DisplayPort 2.1 spec." So yes, any GPU, Docking Station, monitor, cable (or anything) certified for DisplayPort 2.0 will fall under the stricter newer v2.1 specification.

"DisplayPort 2.1 is more than just backward compatible with DisplayPort 2.0."

VESA says one of the most important things it has tried to achieve with this update is to offer a robust experience. This philosophy applies to users connecting peripherals via a native DisplayPort cable, via DisplayPort Alt Mode (DisplayPort over the USB Type-C connector), or tunnelling through the USB4 link. Whichever solution you might use, the alignment of the spec and PHY (physical layer) has been tightened for dependability.

So, if all these things remain the same, and DisplayPort 2.0 and 2.1 are interchangeable, you might be wondering what's the point of the new specification. Perhaps the most important introduction is the new DisplayPort bandwidth management feature "to enable DisplayPort tunnelling to coexist with other I/O data traffic more efficiently over the USB4 link." According to the VESA press release, this efficiency comes on top of new mandated support for VESA's visually lossless Display Stream Compression (DSC) codec and VESA's Panel Replay capability. VESA's DSC implementation will reduce bandwidth usage by as much as 67 percent without visual artefacts. Moreover, the new Panel Replay capability can reduce tunnelling packet transport bandwidth by over 99 percent in certain situations.

VESA Board Chair and VESA DisplayPort Task Group Chair Alan Kobayashi boldly claimed that the higher bitrates supported by DisplayPort 2.1 "offers ample bandwidth for the needs of virtually every practical application."

The announcement also revealed that cable specs were updated. With DisplayPort 2.1, VESA aims to allow for improved capabilities and longer cable lengths, sometimes extending over two meters. "VESA certified DP40 cables support up to the UHBR10 link rate (10 Gbps), with four lanes, providing a maximum throughput of 40 Gbps," VESA explains. "VESA certified DP80 cables support up to the UHBR20 link rate (20 Gbps), with four lanes, providing a maximum throughput of 80 Gbps."

Interestingly, ex-HardOCP Editor-in-Chief Kyle Bennett tweeted at the time that multiple sources had indicated to him that AMD Radeon Navi 31 GPUs would offer support for the DisplayPort 2.1 specification. This summer, there were rumours of RDNA 3 supporting DisplayPort 2.0 and UHBR20. Intel Arc LE model GPUs also support DisplayPort 2.0. Considering what VESA has said, both the AMD and Intel GPUs will support DisplayPort 2.1. Putting these into competitive perspective, the recently launched Nvidia Ada Lovelace flagship, the GeForce RTX 4090, supports DisplayPort 1.4.

Mark Tyson ■

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ON SALE NOW

END USER

Elon Musk bought Twitter to destroy it

A series of hastily-implemented rules is tearing the platform apart, but are they blunders or deliberate tactics? Questions Shaun Prescott.

Shaun is an Australian editor for *PC Gamer*, *GamesRadar* and *PLAY*, and writes for *APC*, *TechRadar* and more.

Last month Elon Musk – best known as the billionaire who smoked weed on Joe Rogan's podcast – bought Twitter for US$44 billion. At the time of writing, mere days after the space guy took the bird site's reins, the site is in chaos. It's in chaos, not because one of Musk's first actions was to lay off 3,700 staff – in other words, half of the company's workforce, including those in the company's Australian office – but because of a series of seemingly off-the-cuff implementations dreamt up by the genius billionaire himself.

The first was changing the site's verification system. For those lucky souls unfamiliar with Twitter, verification used to work like this: public figures and organisations, including politicians, corporate entities, celebrities, news outlets, and more, are normally "verified" with a blue checkmark, which indicates that Twitter has confirmed that the account is legitimate. Musk did away with the useful simplicity of this concept, opting instead to charge US$8 (formerly US$30!) for the privilege. Not only that, he opened the privilege to everyone. He described the move as a demonstration of his commitment to free speech. "Widespread verification will democratise journalism and empower the voice of the people," he tweeted, presumably between huffs of laughing gas.

Anyone with half-a-brain (or else, anyone with a morbid, political interest in simply watching Twitter burn) can see that the idea will only lead to disinformation, a fact that Musk himself must see, because the new verification system roll-out was deliberately timed for after the November United States midterm elections. Sadly, those were not the last elections to ever take place on planet Earth. As I write this, on the first day of the new verification system's rollout, it's starting to feel like April Fool's Day will now be a permanent fixture: baloney announcements by fake verified companies are rolling out at a blinding pace, making disinformation ranging from hilarious though to highly problematic democratically available for anyone with a spare $8.

I'm not hubristic enough to say that Elon Musk is an idiot; he's clearly got some issues, but nor am I hubristic enough to play the psychologist. What appears to be the case here is a contempt for the platform itself, apparently stemming from a vague notion of "freedom of speech" as an expression that means "you can say any old thing that you like on a website" rather than "citizens will not be imprisoned for criticising power" (unless you're Julian Assange, or Chelsea Manning). But let's not go off-piste: what seems to be the operative motive here, is spite: Elon Musk bought the site and clearly intends to slowly destroy the site due to a typically conservative belief that this powerful media entity is controlled by the liberal intelligentsia. (Musk has indicated publicly that his voting allegiance has shifted from Democrats to Republicans, while pointing out his "historical party affiliation has been Independent".)

Whatever the case, it looks like Twitter is dying, and it looks like the lethal injection was deliberate. Is it because the spacefaring billionaire is sick of being bullied on the platform? Or is it for some other, more nefarious reason? Either way, or something else, one thing's for sure: he'll likely tweet about it soon.

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Google's power to profit from propaganda

ProPublica report details just how much money Google still makes on misinformation.

Misinformation is not a problem that began on the internet, nor is it unique to the platform. Everything from pamphlet letterbox-drops to radio and national television broadcasts are capable of regurgitating under-researched or intentionally misleading information, but the internet is a platform that can quickly and dramatically amplify inaccurate messages to a larger and more diverse audience than any other format. We've seen a lot of criticism levelled at the biggest social media companies for encouraging and then profiting off of false information campaigns, yet Google – the fundamental arbitrator of important information on the internet – has only really had occasional scrutiny in this regard, despite numerous critics attempting to quantify just how much of an influence the company could have had on democratic proceedings like the outcome of the 2016 US elections.

For the most part, it's not of much concern to public interest how Google decides which page is the first to come up in a search result. Most rankings are largely governed by how useful people find the information, a self-regulating system that works well enough for arranging benign information and even capitalist ventures, but misinformation has a tendency to play into people's prejudices and is popular enough to cheat his self regulating system.

An in-depth report released in October by the US based *ProPublica* investigative journalism publication, dissected years of research into the ad revenues of Alphabet's primary company in some non-English speaking regions of the world to see if election interference or other misinformation propagation could be being overlooked by Google.

The study found that in Brazil, Google was running ads on a wide range of sites that were publishing false information about the country's electronic voting system, a decision that funnelled considerable revenue into outlets that were open to running false information that benefited the campaign of incumbent president, Jair Bolsonaro. Out of a list of 262 websites flagged by a local fact checking organisation as regularly publishing false or misleading information, Google was serving ads and providing revenue to 121 of them. If that list was confined to just the top 30 most shared sites, Google was helping provide revenue to 80 percent of them. This undoubtedly helped the country's largest dubious publications continue to produce misleading information, a fact that directly contravenes the company's publicly announced policies regarding ad placement.

A more broad, global analysis of COVID-19 misinformation found that Google continued to place ads on 41 percent of 800 active online articles flagged by Poynter Institute's International Fact-Checking Network as containing false COVID-19 claims. It also still runs ads on 20 percent of the pages listed as containing false climate change information by the well established fact-checking organisation: *Science Feedback*.

Google did remove ads from some sites highlighted by the *ProPublica* report and a spokesperson for the company responded "We've developed extensive measures to tackle misinformation on our platform, including policies that cover elections, COVID-19 and climate change, and work to enforce our policies in over 50 languages."

The spokesperson also acknowledged that the company knows there is more work to do, but the report highlights major oversights in six non-english speaking regions that have the potential to significantly destabilise normal democratic function... so hopefully the investigation can prompt a more stringent response.

Joel Burgess ■

> "For the most part, it's not of much concern to public interest how Google decides which page is the first to come up in a search result."

Joel is one of the senior journalists on *APC* magazine and apart from being the resident laptop, monitor and fitness tech geek, he's also pretty into surfing his local Sydney beach breaks when he's not in front of a screen.

© ProPublica.org

TWO BITS

AMD readies its RTX 4000 challengers

RDNA 3 may have some surprises in store.

Chris has been elbow deep in PCs since before the turn of the millennium, and he wouldn't have it any other way.

I don't know about you, but I never tire of new PC hardware releases. I'm always chasing something better, but not always better performance. A product with similar performance at lower power levels that's cheaper, or has a certain key feature is always welcome in my book.

AMD's first RDNA 3 cards are launching in December. The adoption of a chiplet architecture for a GPU is nothing short of revolutionary. Dealing with the challenges of a chiplet CPU is one thing, but it's much more difficult to do the same for a GPU, which requires huge amounts of low latency bandwidth. It's very exciting.

> "AMD is positioning the RX 7900 XTX not as a 4090 competitor, but against the 4080."

Apart from more shaders and higher clock speeds, 7900 cards feature more memory bandwidth, bigger caches, DisplayPort 2.1 support and the use of 8-pin PCIe power. But, can 7900 cards go toe-to-toe with the RTX 4080, let alone the 4090?

AMD is positioning the RX 7900 XTX not as a 4090 competitor, but against the 4080. Some may be disappointed by that, and though we'll have to wait to see just how both the 7900 XTX and 7900 XT stack up, I'll be impressed if AMD can deliver 4080 beating performance with a combination of lower pricing or lower power consumption. Ray tracing is here to stay, and AMD went to great lengths to improve its ray tracing performance for this generation. Will it be enough to compete? We'll compare FSR 3.0 to DLSS 3 when it's released in 2023.

At the time of writing, the RTX 4080 had yet to receive Australian pricing, though with a USD price of $1,199, AU$2,000 isn't out of the question. The RX 7900 XTX is to be priced at US$999, which would mean AU pricing in the $1,700 range. Compared to the RTX 4090 that starts at AU$3,000, the 7900 XTX at $1,700 or so looks like a relative bargain. But it all depends...

AMD didn't provide direct performance comparisons during its recent launch event in Las Vegas. Things get a little muddied when talking about FSR or DLSS enabled benchmarks, which makes it difficult for apples to apples comparisons. I believe the 7900 XT(X) will beat the RTX 4080. If it can, it should do well in the market, but if the 4080 is consistently ahead, I'd be disappointed. We'll have to wait and see, and we're hoping our independent testing surprises us.

We've got RTX 4080 cards in the labs now, and we'll have reviews of MSI's RTX 4080 Suprim and Asus' RTX 4080 TUF models in our next issue. Once we have a firm idea of just where they sit, we'll have a bar for AMD to aim for.

On the topic of benchmarking, we've taken the opportunity to update the APC test rig, which is set to provide the backbone of all of our hardware testing throughout 2023. An Intel i9 12900K, Asus ROG Z690 Apex and RTX 4090 Founders Edition make for a powerful setup. It's designed to minimise bottlenecks as much as possible, allowing the best 2023 hardware to reach its potential. Why not a 13900K or Ryzen 7000? It's always better to use a mature platform, rather than one that can (and probably will) require repeated re-benching. It's a setup we've discussed internally at length and we feel it's the best platform to use for the coming year. ■

Chris Szewczyk

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Playing cards

Ethereum ends mining, EVGA exits GPU market.

© Getty

The PC landscape is about to see the biggest upheaval in years. AMD Zen 4 CPUs, Intel Raptor Lake, Nvidia Ada Lovelace, and AMD RDNA 3 are all here or coming soon. But perhaps just as big and impactful on the PC enthusiast community is the successful transition of Ethereum from proof of work mining to proof of stake minting – the very next day, EVGA announced that it would be closing down its graphics card division.

Let that sink in. EVGA, the biggest vendor of Nvidia graphics cards in the US – accounting for roughly 40 percent of the market – called it quits one day after mining ended. The two might be unrelated. Nvidia's CEO stated that EVGA's founder Andrew Han had been "thinking about moving on for several years". The time has apparently arrived and Han says he has no plans to sell the company or make cards for other companies. On the other, we can't help but think cryptocurrency played a role.

This boom-and-bust cycle was the fourth since Bitcoin's inception and, in many ways, the most impactful on the world markets. Cryptocurrencies reached a peak market cap of nearly US$3 trillion in November 2021, but their total worth currently sits at less than US$1 trillion. Numerous startups have come and gone, taking investor dollars with them.

Ethereum mining remained profitable, just not as much as at its peak. The best GPUs could still make about $3 per day up until the merge. The network hashrate before then was still plugging along at a heady 900TH/s. To put that in perspective, it would have taken 10 million RTX 3080 cards to power the Ethereum network – and because there were lots of different GPUs participating, it's a reasonable estimate that over 20 million graphics cards were mining Ethereum up to the end.

Now, those cards are in search of some other coin. Except nothing else even comes close. Ethereum constituted up to 97 percent of all GPU mining over the past couple of years. The influx of hashrate to alternative coins has caused profitability to plummet and, with rising electricity costs, most GPUs would spend more on power than they generate in cryptocurrency.

Unless something changes, we expect a flood of used mining GPUs to enter the market. Inventories of new graphics cards have been building up for the past six months, as supply finally outstripped demand. Prices are falling to acceptable levels but are likely to fall even further – that seems to be part of the impetus for EVGA shuttering its graphics division.

Han cited 'disrespect' from Nvidia, pointing to the RTX 3090 Ti Founders Edition pricing, where Nvidia almost halved the price mid-year without giving its partners a heads-up. Instead of making hundreds of dollars off each card sold, EVGA is losing hundreds. This was just too much.

There's more to the story. Nvidia's RTX 4090 and 4080 cards have increased the generational pricing but, after the 3090 Ti, how can Nvidia's partners be sure prices will stay high? If Nvidia can compete with its AIB partners and drop prices to levels they can't hope to match without losing money, the best decision may be to stop playing the game. RIP, EVGA.

Jarrod Walton ■

Jarrod Walton
Jarrod can barely contain his excitement with all these big launches.

> "Perhaps just as big and impactful on the PC enthusiast community is the successful transition of Ethereum from proof of work mining to proof of stake minting."

ONE MORE THING

Shockwaves across the net

The Queen's death has brought out the worst in our new era of internet reporting, says a saddened Jon Honeyball.

"When we say goodbye to Charles will it be an immersive 3D virtual reality experience, where you can travel along with the coffin itself from a top mounted VR camera?"

Jon Honeyball now has a Queen-shaped hole in his life.

The death of Her Majesty has been an object lesson in the internet's place in the transmission of news. We were watching the regular news broadcast when it quickly became clear that notes were being passed amongst the top teams. Live, before our eyes.

With a mastery that only the Palace could manage, the brief messages from the Queen's medical team moved from comfortable to concerned. And when it became known that the close family were rushing north, there was an inevitability to the day.

I write this a handful of days after the official announcements, since when we have had 24-hour news cycles on the major channels, discussing every detail of each move by the Royals. Where they were. Whether the princes had reconciled. Speculation, conjecture and rumour, fuelled by an almost insatiable need for the news channels to "be seen to be doing the right thing". This reached a crescendo in the day immediately following her death, with the social media teams of every company and organisation, small and large, wanting to get their message out. To be seen to be caring. My inbox filled with messages of sadness from every email address I had ever contacted.

Websites went greyscale by the judicious use of a quick "filter: grayscale(1);" being slapped into their CSS. If that was the limit of their careful crafting of a public message, then you could measure their sincerity with a micrometer.

Event after event was cancelled that weekend, often at great cost to the companies attending. The peak nonsense arrived in an email: I had recently bought (and paid for) a remaster reissue of George Michael's album 'Older'. The email from the record company said: "The loss of someone who was loved by so many is profound and so as a mark of respect during a period of national mourning we feel it is appropriate to move the release of Older back to the 30th of September." All I could do was to shake my head in disbelief.

The use of technology by the broadcasters showed just how much has changed in the internet era. Now there could be cameras everywhere, transmitting live footage back to the newsrooms from around the world.

It would be nice to think that the Royal Family might move into a more internet-connected age. That thought lasted for a few nanoseconds, until I struggled with the idea of King Charles III having a Twitter handle. It's bad enough with the lesser Royals having podcasts and a Netflix contract.

But time moves on, and the world changes with it. If anything, the recent events have taught us just how much things have changed, and how well Her Majesty balanced that with the needs of the Crown. But we are now in a more modern, connected world and we must accept what comes with it. Or do our best to tune out from the whole event. How might this run in the future, when we say goodbye to Charles? Will it be an immersive 3D virtual reality experience, where you can travel along with the coffin itself from a top mounted VR camera, allowing you to immerse yourself in a first-person view of the admiring crowds? The whole thought is utterly miserable. I think we have gone too far this time with the coverage, but I accept others will disagree. Going further, however, might be too much for anyone. Even for Meta and Mr Zuckerberg.

Jon Honeyball ■

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FUTURES

WE EXPLORE THE TRENDS AND TECHNOLOGIES THAT ARE SET TO SHAPE THE FUTURE

How quantum computing can fight climate change

Quantum computers could help unpick the challenges of climate change and offer solutions with real impact – but we can't wait for their arrival, says Nicole Kobie.

Technology won't save us from climate change, but it could help – and if quantum computing would hurry up, the leap forward in processing power could help expand our understanding of our changing world, reveal how to reduce the impact of carbon emissions and spark innovations that make a real-world difference.

Rather than have bits that are either on or off, as in standard binary systems, quantum computing uses physics that allows particles to be in multiple states. That means quantum bits (qubits) give this type of computer an exponential jump in processing power. Vital milestones have been reached – Google laid claim to reaching quantum supremacy in 2020, which means its system managed an equation that a standard computer couldn't do.

It's well worth the effort, argues Philipp Ernst, senior expert in the innovation practice at McKinsey, and Niko Mohr, partner at McKinsey Dusseldorf, who have identified five ways that quantum computing could be put to practical use addressing climate change. These five quantum-powered solutions could slash a whopping seven gigatons of carbon emissions by 2035, helping to keep the globe on track to warm by 1.5°C and nothing more, the widely agreed upon target to avoid catastrophe.

That doesn't mean existing climate change mitigation efforts should halt, as there are lots of reasons the arrival of quantum computing could be delayed. But when we develop these powerful computers, they could have real impact.

Where are we now

Quantum computers already exist, but they're small in scale and more qubits are needed for error correction. Still, progress has been made, Ernst says. "If you look back at the last ten years, you basically started with these two, four, five, ten cubit systems. They are in the vicinity of 100 aiming for 1,000 cubits, so this is evolving."

So far, such hardware is known as NISQ – that stands for noisy intermediate-scale quantum. "This is a quantum computer that is working; what it is not yet doing is something commercially useful," said Ernst.

The Bristol experiment is a key step towards quantum cryptography.

The question, according to Ernst, is when can you do something actually useful with quantum computing? "The very rough consensus estimate is that the real breakthroughs can come once you've established error-corrected, fault-tolerant quantum computing," he said. "We're talking orders of magnitude here – it probably needs around a million cubits in order to realise that."

Put another way, Ernst says that because of the noise on the system, existing quantum systems can run about 50 gates, similar in principle to logic gates on a classical computer. To achieve something beyond what an existing computer could do, we'd need around a billion quantum gates.

He predicts that should happen within the second half of this decade, helped by advancements in hardware as well as improvements to algorithms that run on that hardware. However, he notes there is some disagreement, and companies in the industry believe they will be able to do commercially viable work before then.

Quantum technology

Mohr notes that the field really should be referred to as quantum technology, as it also takes in quantum sensing and communications – think measurements and networking.

"Quantum sensing is about measurements and position – gravity and time and electromagnetism, those kinds of topics" he said. "And that ecosystem, especially in the component space, is in mature development, there are products in use already, such as in seismographic applications.

"Quantum communication is all about the transmission of information based on quantum physics, related mainly to secure transmission. One popular use case is post quantum cryptography, which is related to the power of a quantum computer to crack security."

That said, quantum computing is drawing the most research activity as well as the most funding, with an estimated $3 billion spent in 2021, largely in the US and China. Most of the money is focused on hardware, Mohr says, but there are more companies working to develop software.

Of course, it's not as simple as pointing a quantum computer at a problem and a solution magically appearing: first you need to identify the problem you're going to solve and understand what it is you need to simulate. "That's actually work you can start doing now, understanding the specific problem that you want to simulate," said Ernst.

Beyond hardware, we need the right software and systems to run simulation applications, which in turn also need to be developed. Companies need to offer this as a service as well, as most researchers won't have a quantum setup in their own labs.

In short, we need a fully functioning ecosystem with a top layer of easy-to-access services for those who need to tap into quantum technology's power.

What can it do?

One of the most compelling use cases for quantum computing is modelling and simulation, and that could enable breakthroughs by researchers in a range of topics, from green energy to slashing industrial carbon.

Consider solar panels. They've been an unquestionable success, with costs falling 82 percent over the past decade, becoming one of the cheapest sources of energy. However, existing panels have an efficiency rate of about 20 percent, meaning that's the amount of energy they manage to capture, with the rest lost. Improving that would make solar panels significantly more important in terms of national energy creation, particularly in places that get less sun.

Above: Quantum computers could make solar panels far more efficient.

A solution has already been spotted using a crystalline structure called perovskites. But there are billions of options for the arrangement of molecules and the materials to make them, and development is currently a matter of trial and error. "Perovskites are just a structure where you can put different atoms in... creating different physical properties," Ernst said. "You're trying to synthesise a new compound with a better yield, but there are problems in terms of durability and toxicity. It takes tons of time to cycle through all these questions."

Because of that, progress is slow. "Perovskite research has actually slowed down – it will be slow and incremental," Ernst said of the existing approach.

A quantum computer would make short work of it. "You could effectively identify the specific compounds that would have a high efficiency, basically increasing it from 20 to 25 percent where it currently is for solar cells to a theoretical limit of 40 percent," Ernst explained. Then the material needs to be produced and fashioned into solar cells at a mass scale, but once that's achieved it should lead to a step-change in power generation.

Perovskite solar cells are at the forefront of quantum research.

Where else?

And that's just one area where quantum could help. McKinsey also identifies other areas where quantum computing could yield real results. For example, green hydrogen was – before fuel prices went berserk – 60 percent more expensive than natural gas. By optimising the procedure to produce green hydrogen, known as electrolysis, the process could become significantly more efficient, pushing the cost below emissions-spewing gases. The same could follow for green ammonia, McKinsey argues, helping to decarbonise the shipping industry.

Detailed modelling that isn't available today could help do the same for batteries, increasing energy density through chemical breakthroughs, letting them power lorries to slash emissions from transport and support renewables on the power grid. Simulating material makeups for new, reduced carbon cements could solve a little-known source of immense amounts of emissions, while finally cracking carbon capture could be possible thanks to accurate modelling rather than trial and error.

One last major source of emissions is cows. Research suggests it would be possible to reduce methane expulsion from cattle via a vaccine – an anti-fart jab for cows – but development right now is down to trial and error. A quantum computer could make light work of it, letting researchers unpick the perfect molecule for this important, but odd, job.

McKinsey argues that applying quantum computing to those eight areas could save enough emissions to get the world back on track to net zero before 2050. That includes creating higher-density batteries for lorries and grids (1.4 gigatons of CO_2 emissions), decarbonising cement (1.5 gigatons) and the development of direct-air carbon capture (0.7 gigatons), perovskites in solar panels (0.4 gigatons), affordable green hydrogen (1.1 gigatons) and green ammonia

Above: Green hydrogen could help reduce carbon emissions for public transport.

(0.6 gigatons), and an anti-methane vaccine for cattle (1.1 gigatons).

What's next?

For all of this to work as quickly as possible, we need not only working quantum hardware – a massive challenge in its own right – but also the components to build the hardware, software to operate systems, and platforms for researchers to easily run their apps and modelling. "In the end, it's about developing a fully fledged ecosystem, starting from the components fully through to the tech stack with services on top, which needs to be in place," said Mohr.

Before that happens, we'll likely see the use of hybrid systems, with classical computers paired with quantum power, dividing problems into pieces that each type of computing can handle. "That's how we envision the next step, which we will probably see in the next two to three years," Mohr said.

Once such systems, be they hybrid or full quantum, are up and running, how do we ensure they're used to solve the most serious issues facing society? In some cases, the market will drive it, says Ernst, noting that anyone who can significantly boost the efficiency of solar panels will find plenty of customers. But some of the other ideas might need a bit of help. "I believe in the end this can only be a combination of government support, philanthropic support and visionaries that will enable some of the use cases that are not the most attractive economically, but will have huge impact," said Ernst.

And there are plenty of areas where the processing power boom of quantum computing could be applied to benefit us all. Mohr points to human health, using advanced modelling to better understand diseases and treatments for them, as well as optimising transport networks and routes to reduce pollution and traffic. As with any technology, there are potential downsides – the ability to break existing encryption is one – and Mohr calls for us to make good use of the time we have left before the arrival of quantum systems to put in place frameworks, monitoring and laws to avoid misuse.

Perhaps the biggest downside of quantum computing's potential to battle climate change is that it leaves some believing we can wait for technology to rescue us. That's not the case, argues Ernst. "You obviously need to continue with other efforts," he said. "What we've modelled is that the impact of quantum computing can be significant, but it's on top of [other] measures. Given the importance of this problem, you basically need to do everything you can."

WHAT IS QUANTUM COMPUTING?

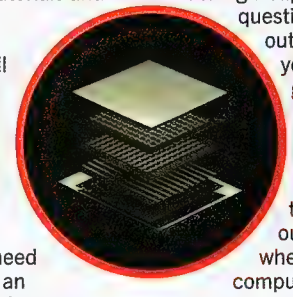
The next generation of computing is on the horizon, with an exponential leap in processing power.

Quantum computers, and adjacent technologies such as quantum networks, could change the way we process data, ripping through existing cryptography and enabling world-changing modelling. But first we'll have to build them – and figure out how to use them.

At a basic level, traditional computers use binary – every bit is either off or on. That we manage so much with so little is frankly amazing. But quantum takes this further with quantum bits, which have been rather cutely dubbed "qubits". Thanks to quirky quantum physics, rather than just two positions, qubits can be off or on or both or neither, an idea called superposition. Add to that entanglement – the idea that qubits can interact – and that gives quantum computers exponential processing power over our existing computers, including supercomputers.

WHY DON'T WE HAVE THEM YET?

Harnessing quantum physics is no easy task. Beyond figuring out how to build one, and sourcing materials and components, quantum computing is full of errors – and they need correcting. Because of the huge amounts of error correction required, we'll need computers with an excess of qubits in order to fix their own mistakes. And, to be clear, quantum computers already exist.



Above: A representation of IBM's Eagle quantum computer, which has 127 qubits.

Who's making them? IBM's quantum computer is currently deemed the largest, with 127 qubits. The Eagle, as it's dubbed, is what's known as a superconducting quantum computer, which means it's built using electronic circuits. Google and Chinese university USTC are using similar models, as are Intel and Rigetti.

Canadian startup Xanadu is building a photonics-based machine that uses light as a conductor, while D-Wave is using a technique called quantum annealing. There are different types, and they're all bewilderingly confusing: trapped ion, quantum dot, molecular magnet and many more.

Some of this hardware is already available to access via the cloud, letting researchers and businesses access early iterations of machines to start to understand them and develop applications. This is likely one way quantum computers will be accessed when they do truly, fully arrive, as such intricate and expensive hardware will be well beyond the means of all but the best funded labs.

WHAT IS QUANTUM SUPREMACY?

Quantum computers are still just computers running equations, and there's in theory nothing that a quantum model could do that a traditional binary design also couldn't manage, given all the time in the world. Time is the key difference: quantum computers can manage tasks that would take existing computers far too long – there's not much point in asking a supercomputer a question and spitting out the answer for your grandchildren to collect, after all.

Quantum supremacy is the point where the qubits outpace the bits, when a quantum computer can solve an equation that no classical computer could do in a reasonable amount of time. Depending on who you ask, that nut has already been cracked, by Google's Sycamore in 2019. IBM disagrees, saying the equation done by Sycamore could be managed by a supercomputer it built called Summit. Since then, Chinese researchers also claim to have managed the milestone.

Given we're in such early days of quantum development, that suggests supremacy isn't a very useful milestone. ■

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PREMIUM LAPTOPS

APPLE MACBOOK PRO 14IN

STUNNING CREATIVE POWER

Alongside its 16-inch sibling, this is simply the world's best laptop for demanding users. The amount of power on tap via the M1 Pro or M1 Max processor is staggering, and it's backed up by a terrific screen and stunning battery life. With all the ports you could ask for, the only negatives are its relative bulk (especially compared to the Air) and high price.

From $2,999, apple.com/au

BUSINESS LAPTOPS

DELL XPS 13 PLUS

DELL'S NEW FLAGSHIP IS A STUNNER.

The updated XPS's headline features include a notably more powerful Intel 12th generation CPU, an optional OLED touchscreen panel, an integrated glass touchpad palmrest and a neat capacitive touch bar. A powerful luxury laptop that's up there with the very best.

$2,339, dell.com/en-au

ALTERNATIVES

DELL XPS 15 (2022)

Surely the best Windows all-rounder money can buy, with a slim design, gaming potential and plenty of power courtesy of Intel's 12th gen Core processors.

From $2,924, dell.com

APPLE MACBOOK AIR

The MacBook Air M2 looks like a standout to us. A powerful and quiet ultraportable with an unbeatable battery life and a great pro display.

From $1,899, apple.com/au

ASUS VIVOBOOK PRO 16X OLED

Top notch components, an amazing OLED display and leading battery life make this an exceptional Ultrabook for creatives.

$2,299, asus.com/au

ALTERNATIVES

NEW ENTRY

LENOVO THINKPAD Z13 GEN 1

The perfect laptop for executives, with amazing battery life backed up by strong performance. A great debut for the Ryzen Pro 6850U.

$2,929, lenovo.com/au

LENOVO THINKPAD X1 CARBON GEN 9

A business laptop with heaps of luxury, especially if you choose the top-end model with a 3,840 x 2,400 screen.

$2,959, lenovo.com/au

DYNABOOK PORTEGE X30W-J

This 2-in-1 convertible is ludicrously light and slim, and offers a quiet keyboard, great performance, ports a-plenty, and a nice touchscreen.

$2,083, anz.dynabook.com

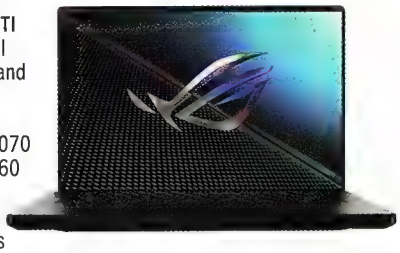
GAMING LAPTOPS

ASUS ROG ZEPHYRUS M16 (2022)

I9-12900H AND AN RTX 3070TI

2022 will see an update for all mainstream gaming laptops, and Asus is first to jump in with a 12th gen Core i9 CPU to give 16-core support to the RTX 3070 Ti graphics (a Core i7/RTX 3060 variant costs $2,999). While battery life is only average at around six hours, this laptop's final triumph is fitting a gorgeous 16-inch screen into such a compact chassis.

$4,499, asus.com/au



EVERYDAY LAPTOPS

MICROSOFT SURFACE LAPTOP GO 2

FEELS LIKE A PREMIUM ULTRABOOK, BUT COSTS HALF AS MUCH.

A solid update to an amazingly good value mid range ultrabook. It runs cool and quiet, and has up to 30 percent better battery performance than its predeccessor, all in a beautifully designed form with a superb keyboard and trackpad.

From $1,099, microsoft.com/en-au

ALTERNATIVES

LENOVO LEGION 5I PRO (16IN)

A great-value gaming laptop that's extracts the most from its powerful components. We really love the keyboard, too.

From $2,649, lenovo.com/au

ASUS ROG STRIX SCAR 17 SE

An extremely high performance esports gaming laptop that was a good 15 percent faster than any other laptop we had on file.

$5,799, asus.com/au

ASUS ROG ZEPHYRUS G14 (2022)

A powerful gaming ultraportable that lights up for both work and play. The AMD CPU and GPU balance well.

$3,499, asus.com/au

ALTERNATIVES

LENOVO YOGA SLIM 7 PRO

A powerful, well designed ultrabook with an awesome OLED screen for a good price. The original 2-in-1 bends into a new clamshell shape.

$1,699, lenovo.com

HP ENVY 13 (2020)

It may not be the world's most exciting laptop, but the Envy 13 is a compact and forward-looking machine that's ideally suited to these homeworking times.

$1,699, store.hp.com

HP PAVILION 14

This slim 1.4kg laptop is a superb choice for anyone on a tighter budget. it struck an excellent balance between speed and battery life – around ten hours.

From $999, store.hp.com

CHROMEBOOKS

ASUS CHROMEBOOK FLIP CX5

The best big-screen Chromebook we've tried, with a bright 15.6in Full HD display with decent black levels and surprisingly rich colours. And it's a good specification for the price, with a Core i3 processor, 8GB of RAM and a 128GB SSD in tow.

$1,213, asus.com/au

LENOVO FLEX 3 CHROMEBOOK

This isn't the most powerful Chromebook, but students need reliability more than power – especially if they're only really using it for homework, note-taking, and perhaps the occasional bit of Netflix.

$484, lenovo.com/au

LENOVO IDEAPAD DUET

The Chromebook answer to Microsoft's Surface tablets, this is a seriously versatile device – albeit not the speediest (although we never found it to be painfully slow while carrying out everyday tasks). For this price, and with a 16hrs 14mins battery life, the Duet is a great choice.

$899, lenovo.com/au

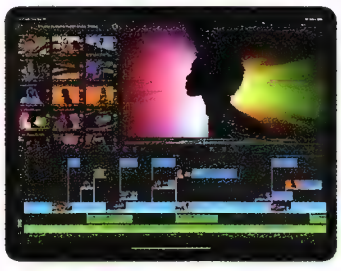
TABLETS

APPLE IPAD PRO 12.9IN (2021)

M1 POWER IN YOUR PALM FROM $1,199

Blurring the boundaries between laptop and tablet like never before, the M1-powered iPad Pro 12.9-inch is every bit as fast as we expected – and the "Liquid Retina XDR" display is simply phenomenal.

From $1,649, apple.com/au



APPLE IPAD (2021)

Apple performs its usual trick of upgrading just enough to keep the iPad affordable and up to date, without treading on the toes of its more luxurious stablemates. The big bezels remain, but a faster processor, more storage and improved camera all add to its appeal.

From $499, apple.com/au

SAMSUNG GALAXY S8 ULTRA

The Samsung Galaxy Tab S8 Ultra is an enormously impressive tablet. It makes a fantastic first impression with its gorgeous screen and thin body, and is great for multitasking. If you want the best Android tablet going, there's no question at all that this is it.

$1,499, samsung.com

EVERYDAY MONITORS

PHILIPS BRILLIANCE 346P1C

34-INCH CURVED DOCKING,

No-one can match Philips for its mix of quality, features and value, especially when it comes to curved MVA monitors such as this. It's great for casual gamers and busy workers alike, with USB-C docking and superb colours.

$849, philips.com.au

EIZO FLEXSCAN EV2480

Businesses in particular will love this easy-to-roll-out 24-inch monitor, with its exceptional five-year warranty, USB-C port for easy docking, excellent viewing angles and delicious whites. And it has the best OSD around.

$699, eizoglobal.com

DAHUA DHI-LM28-F420

This affordable 4K monitor might not offer much in the way of menu options or high-end gaming perks, but it offers impressive resolution and colour for ally pay.

$269, dahuaaustralia.com.au

PROFESSIONAL MONITORS

EIZO COLOREDGE CG319X

CREATIVE MASTERCLASS, $7,119

As the price indicates, this monitor is for heavyweight creatives who demand the best in every discipline: HDR video editing, print layouts, professional photography and more besides. With superb coverage and accuracy across all spaces, plus a built-in calibrator, it justifies the investment.

$7,119, eizoglobal.com

BENQ PD2725U

By no means a cheap 4K 27-inch monitor – unless you compare it to the Eizos – but it marries all-round quality with ease of use thanks to a puck that allows you to quickly move between settings. You can even daisy chain a second Thunderbolt 3 monitor for a monster setup.

$1,799, benq.com

EIZO COLOREDGE CG279X

Designers who need to work across different disciplines will love how easy it is to switch between the Adobe RGB, DCI-P3 and sRGB colour spaces using the Eizo's fantastic OSD. It's certainly not cheap for a 27-inch 1440p monitor, but it's packed with quality.

$3,095, eizoglobal.com

HOME OFFICE PRINTERS

EPSON ECOTANK ET-1810

BACK TO BASICS

There's nothing flashy about this bottle- fed inkjet: it's there to churn out pages at a decent rate (8.8ppm for black text) for a low price. It comes with enough ink for 4,500 black pages and 7,500 in colour, but refills are cheap. Just don't expect features like duplex printing.

$299, epson.com.au

CANON PIXMA PRO-200

Yes, it's big and it's expensive – and you don't even get a scanner – but the Pixma Pro-200 means that you can print A3 photos with glorious colour accuracy and detail. If you're after an office workhorse, look elsewhere, but it can't be beaten on photo quality.

$809, canon.com

BROTHER MFC-J4540DWXL

Home workers will love this inkjet all-in-one. It combines an incredible range of features with all the connectivity you need and extreme ease of use. Output quality is fine, it offers the best cloud support around and the high-capacity ink pack could keep you going for years.

$420, brother.com

WIRELESS ROUTERS

■ NEW ENTRY

SYNOLOGY WRX560
THE PERFECT ROUTER
Its quad-band Wi-Fi smashed-through our performance tests managing 791.5Mbps up close, 375Mbps two rooms away and an amazing 216.7Mbps down the garden..
$599, synology.com/au

ASUS RT-AX82U
The impressive RT-AX82U punches well above its price when it comes to raw Wi-Fi 6 performance and includes a fistful of useful features – such as an ultrafast 20Gbits/sec USB connector, outbound VPN support, site-blocking and a host of parental controls.
$320, asus.com/au

SYNOLOGY RT6600AX
Fast, well-featured and secure, the Synology RT6600ax is as perfect for professionals and prosumers as much as it is for SMBs and smart homes, and the app and interface are a delight to use for both experts and plug and play users alike.
$599, synology.com/au

MESH WI-FI

TP-LINK DECO XE75 AXE5400
SUPERB WI-FI 6 MESH
Offers the simplicity, speed and range most people want from a mesh system. While it's expensive, nothing else offers the plug-and-play simplicity, speed and range afforded by the Deco XE75.
$999, tp-ink.com

TP-LINK DECO X20
The price below isn't a typo: the Deco X20 makes it possible to upgrade your home network to Wi-Fi 6 – as well as manage its security – for the price of some standalone routers. The included HomeCare functions are also a great bonus for households where lots of devices are fighting over the bandwidth. **$199, tp-link.com**

ASUS ZENWIFI AX
The interface and design certainly aren't the prettiest (the nodes look like mini space heaters, while the charcoal version is straight out of the 1980s), but if you're after strong performance, great features and plenty of expansion potential, the ZenWiFi AX is a compelling prospect.
$949, asus.com/au

NAS SERVERS

QNAP TS-130
SIMPLE HOME NAS
An above average CPU and RAM combo, solid features and affordable price make the QNAP TS-130 worth considering. Alternatively there's the two bay TS230 which features the same CPU, with 2GB of RAM, dual drive bays, and an extra USB port on the front for a modest $50 price increase.
$250, qnap.com

ASUSTOR NIMBUSTOR AS5304T
This is a hugely powerful four-bay NAS that will be overkill for most people – not just due to its speed but also its slightly intimidating user interface – but techies and gamers should investigate the Nimbustor AS5304T for both its speed and flexibility.
$799, asustor.com

SYNOLOGY DISKSTATION DS1522+
At $1,199 it's not cheap but factoring in the software means it's great value. Though some internal silicon may lack headroom, this is still a well-featured, expandable NAS with fantastic software. The best part is the DSM software.
$1,199, synology.com

SECURITY SOFTWARE

F-SECURE SAFE
F-Secure concentrates on the basics: faultless protection with minimal impact on your system's performance – for a low price.
1-3 PCs, 1yr, $99.99, f-secure.com

VPNs

NORDVPN
NordVPN provides consistent and fast speeds, serious security, great support for video-streaming services and some cost-effective subscription rates.
$59 per year, nordvpn.com

PASSWORD MANAGERS

BITWARDEN
Bitwarden has a huge advantage: it's free. It isn't as slick as some paid-for rivals, but it can sync passwords across all devices for no extra charge. **Free, bitwarden.com**

ALTERNATIVES

NORTON 360
Consistently on the podium in our group tests, and loaded with an abundance of genuinely useful features, including a VPN and generous cloud backup.
1 PC, 1yr, $79.99, nortonlifelockpartner.com

AVAST FREE ANTIVIRUS
For the second year running, Avast is our top pick for free antivirus software – it's simply lighter on its feet than Microsoft Windows Security, whilst offering fewer false positives.
Free, avast.com

ALTERNATIVES

PROTONVPN
ProtonVPN provided one of the best free offerings of all the VPNs in our group test, including unlimited data, but upgrade to benefit from even faster speeds and many more options.
Free, protonvpn.com

SURFSHARK
A strong rival to NordVPN, especially if you're willing to commit to its two-year contract. It's fast, cheap and a fine choice for people who like to switch to US streaming services.
$66.34 for one year, surfshark.com

ALTERNATIVES

DASHLANE
A manager that's ideal for beginners, and it even builds in an unlimited (if basic) VPN service. Note you may prefer to buy the Family plan ($60 per year) as this extends the service to six people.
$55.99 per year (Premium), dashlane.com

1PASSWORD
1Password is targeted at technically minded users who are looking for the last word in security. It even offers a Travel Mode that may ease your mind if surrendering your phone to customs officials.
$54.99 per year (individual), 1password.com

The Top 5 Nvidia GPUs

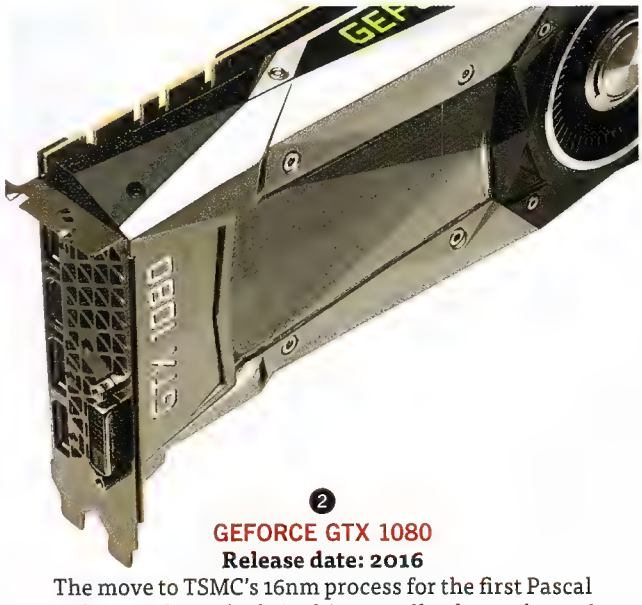
With the launch of the RTX 4090, Nvidia has maintained its position as the manufacturer of the world's fastest consumer graphics card. But it's been a long road, one that has taken it from starting out in the highly competitive 90s era of 3D specialists to acquiring one-time rival 3dfx, working on the first Xbox, and now supplying the graphics tech for the Nintendo Switch. But the real story has always been its fight with AMD/ATI. Here are the GPUs that fought on the front lines.

1

GEFORCE RTX 3080

Release date: 2020

The RTX 20-series was a disappointment, being only a little faster than the 1000-series, but with ray tracing and deep learning super sampling (DLSS), neither of which were quite ready for the mainstream. Thankfully, AMD brought some competition with its RX 5000 series, making Nvidia pull out the stops for the RTX 30-series, with a new Samsung 8nm process, better ray tracing, and DLSS 2.0.



2

GEFORCE GTX 1080

Release date: 2016

The move to TSMC's 16nm process for the first Pascal cards was a huge deal. Architecturally, the card wasn't too different from the previous Maxwell design, but the leap in performance from 28nm to 16nm was huge. AMD, trying to leap to its own 14nm process, had no answer, leaving Nvidia to become the de facto graphics company for years.

3

GEFORCE GTX 680

Release date: 2012

By 2012, Nvidia was making high-end cards while AMD focused on the value end of the market, but both were racing towards producing a 28nm node. AMD got there first with its HD 7000 series but Nvidia blew it out of the water with the GTX 680, which was powerful but also reasonably priced.

4

GEFORCE 8800 SERIES

Release date: 2006

By 2002, the competition between Nvidia and ATI was fierce, leading to bigger and better boards. ATI pushed the envelope with its 200mm-size Radeon 9000 cards, but Nvidia laid down the gauntlet in 2006 with this 300mm beast. It was expensive, but also a true flagship with a performance that meant many owners held onto it for years after buying it. In the same year, AMD bought ATI.

5

NVIDIA GEFORCE 256

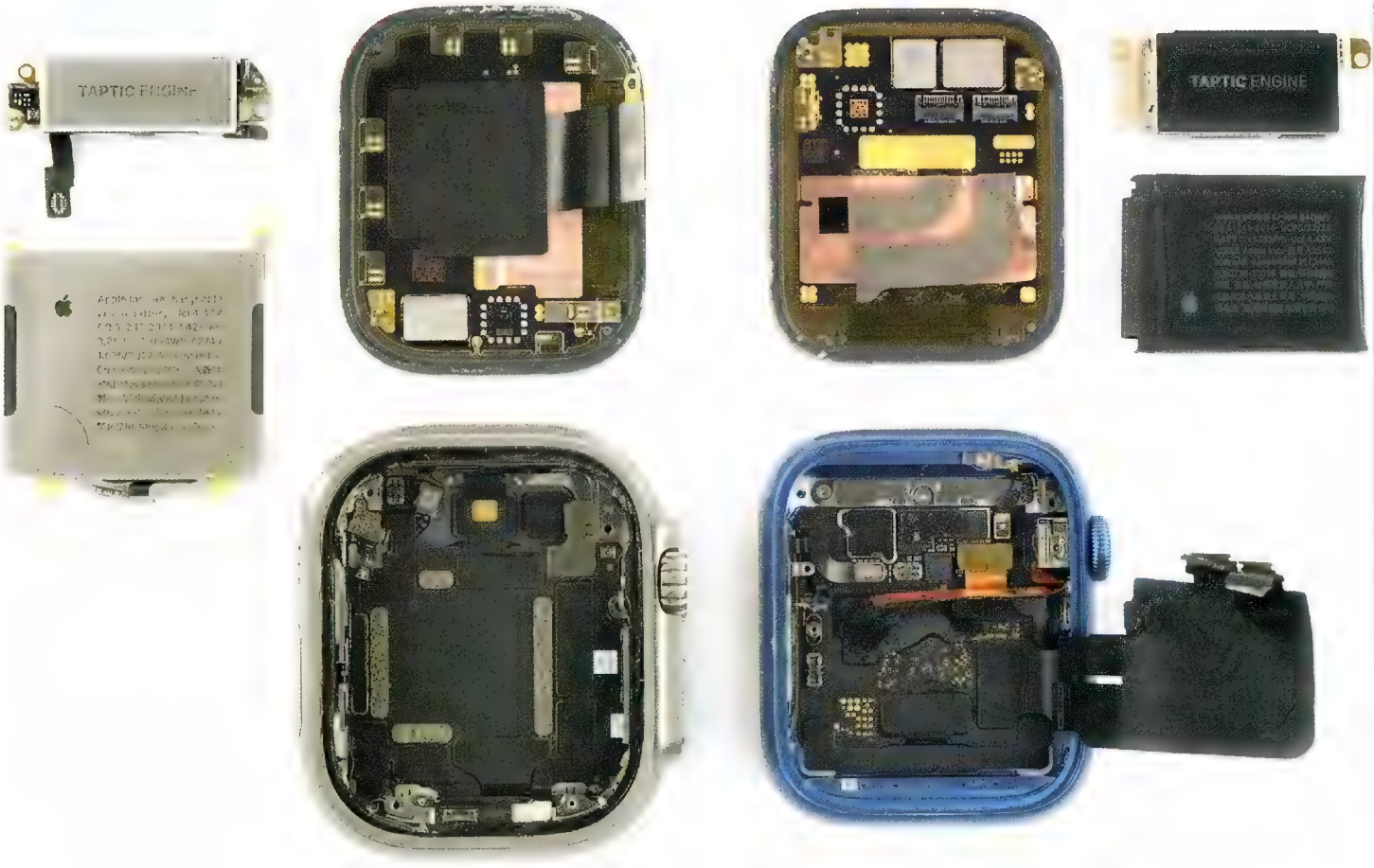
Release date: 1999

The card that put Nvidia on the map is notable for two things – it took 3D rendering tasks away from the CPU and directly onto the graphics card, causing Nvidia to coin the term 'GPU' or Graphics Processing Unit. The initial release was something of a flop because of its use of Single Data Rate memory, the better-performing DDR version came shortly after.

HOW IT WORKS

Apple Watch Ultra

Apple's first extreme sports wearable promises 'ultra' everything, from durability to battery life and features. Whether you're climbing a mountain or diving in an ocean, Apple's watch is built for exploring.



Above: The Ultra (left) packs a much larger battery than the Series 7 (right).
Right: To remove the battery from the case, you'll need to use an opening pick to lift it up.

Left: Before starting repairs, take your watch off the charger and power it down.

Above: The Ultra is sealed using four screws, a first for an Apple Watch. Though they are fiddly pentalobe screws, it's better than glue.

Right: Removing the bottom panel is likely to damage internal components. Even then, Apple's System in a Package (SIP) prevents access to the battery.

Right: Lifting up the screen is incredibly tough and requires a good opening tool and lots of patience. You'll need to do it though, as it's where the battery is held.

Major tech specs

- Screen: 49mm
- Display: 410x502 pixels, 2000 nits brightness, Always-On OLED
- Storage: 32GB
- Chips: S8 with 64-bit dual-core processor, W3, U1
- Connectivity: LTE and UMTS8, Wi-Fi, Bluetooth 5.3
- Battery life: Up to 36 hours (Wi-Fi), Up to 18 hours (LTE)
- Siren: 86 decibels
- Water resistance: 100m
- Diving depth: 40m
- Weight: 61.3g

Key findings

- This is the first Apple Watch to be accessible using screws, albeit the fiddly pentalobe variety. Maybe Apple appreciates this watch is more likely to need fixing? But the party is short-lived, as removing the back shreds the clear gasket Apple has used to aid waterproofing. Replacing this won't be fun at all.
- There's more bad news. After applying some heat to pry off the rear of the case, one of the band release button springs comes flying out. And all that's revealed is Apple's System in a Package (SIP), which blocks all access to the watch's internals. It means that to access the battery, we have to go in via the front display.
- We applaud the ease of accessibility on the back of the watch, but all it's good for is replacing the sensor module that goes against the wearer's wrist. Like the iPhone 14, these changes seem to have been made to improve the experience for Apple Geniuses repairing in-store, but battery swaps will require specialist equipment or, more likely, need to be sent away.
- That means we need to go through the front to get to the other internal components in this watch. Getting through a standard Apple Watch's front display is challenging, but the Ultra is extra-durable. The seams are tight, the prying angle is steep, and the risk of separating the display from the glass is high.
- Release the display from the body, however, and you're straight into the battery. Apple has used the same metal casing for the battery that it's been using in its smaller-model watches since the Series 5. It protects the battery and uses four Y000 screws to secure it rather than glue, which is preferable for repairers.
- Opening previous watches also destroyed a gasket responsible for Force Touch, which is not the case on the Ultra.
- There are other interesting discoveries. The Taptic Engine is huge – 50 percent bigger than on the standard Series 8, and at 9.8g, 16 percent of the watch's overall weight. The speaker has a dual 'split' design, one for the Siren and one for the regular speaker end. Apple boasts of 86 decibels from the siren, which sounds impressive but is only as loud as an alarm clock.
- Repairability score: 3 out of 10 (10 is easiest to repair). From an engineering perspective, the Apple Watch Ultra is an incredible product, particularly the crazy-complex case that houses the antennae and depth sensor. However, the difficulty of accessing the battery is a problem for hobbyist fixers. Though you can replace the rear glass and sensor, you risk losing or breaking parts in the process. Everything else requires you to open from the front and risk shattering that fancy OLED screen. ■

ABOUT IFIXIT

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit **www.ifixit.com**

HEAD TO HEAD

Gmail vs. Outlook

What's the best platform for managing your email?

■ GMAIL | $free | www.gmail.com ■ OUTLOOK | $free | www.outlook.com

About 10 years ago, a previous employer of mine decided to move its email provider from Microsoft to Google. I was overjoyed. At the time, Outlook was tired, clunky, and ugly, while Gmail had a beautiful interface, a proper mobile app, and the ability to enable add-ons. This included one that could delay sending your email so you could go back and edit it or, for an ill-advised 11pm rant to the boss, delete it completely in the morning.

While Gmail is still the better-looking of the two, much has changed in the intervening years. Microsoft has improved its mobile apps, Microsoft 365 has become an integral part of the Windows 10 and Windows 11 experience, and new features such as the ability to see all your attachments in one place are genuinely useful. Gmail hasn't rested on its laurels either, rolling out new features such as the ever-popular Smart Compose predictive text input. It has also reduced users' storage, which combined with the back-pedaling of unlimited free Google Photos, is clearly an attempt to nudge users towards a paid subscription tier.

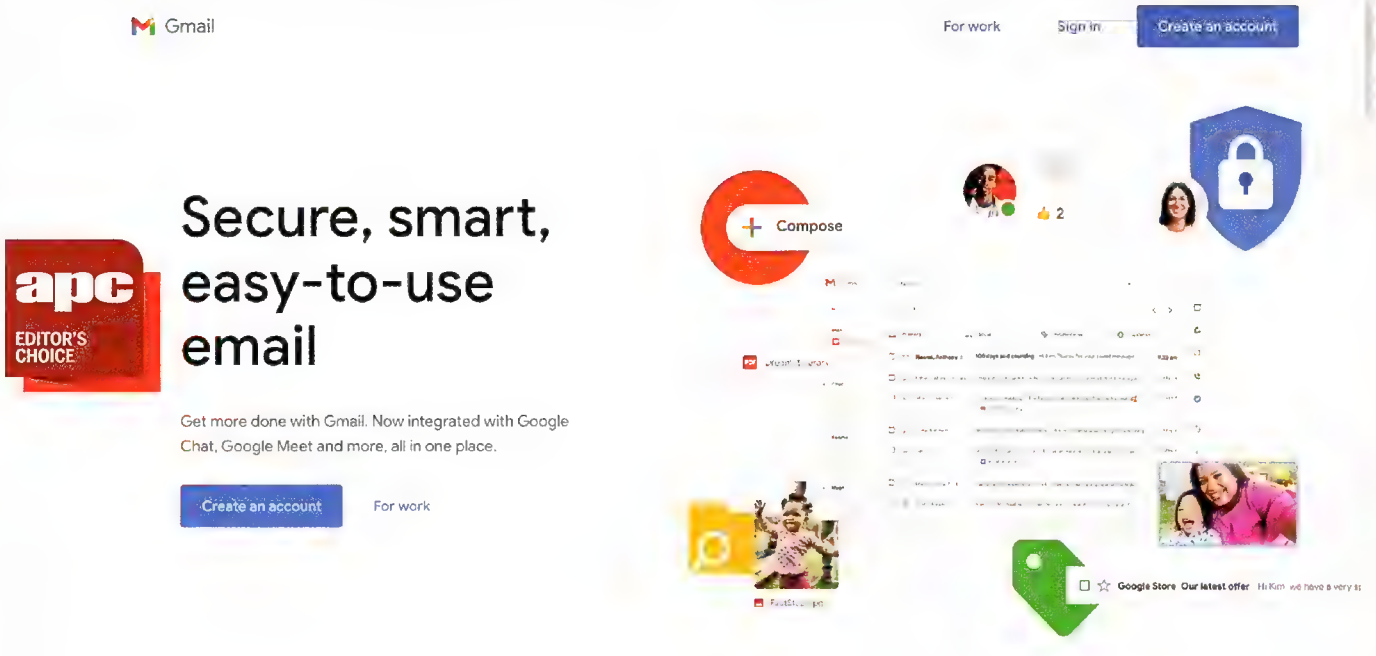
Let's start with Google because it feels like the default email provider for many. Gmail launched in 2004 with the promise of "never delete another email". It even had a ticker on the home page showing how its storage was gradually rising to cope with the new emails it was receiving.

Indeed, in 2006, Google told analysts that it was offering users "infinite storage", as it wanted people to store the "Golden Copy" of their data online and use local-machine versions as a cache. Back then, there was less demand upon email inboxes to cope with marketing blasts, scammers, and huge file attachments, and it fitted in with Google's stated business model, which was to harvest data to serve better advertisements. But along the way, whether due to rising storage costs, the industry's move towards recurring revenue, or a combination of both, Google started charging users for storage. Most users now have 15GB of free storage across all of Google's apps (the main storage hogs being Drive, Photos, and Gmail) before they are then forced to either delete content from their storage, or move onto the Basic 100GB storage plan.

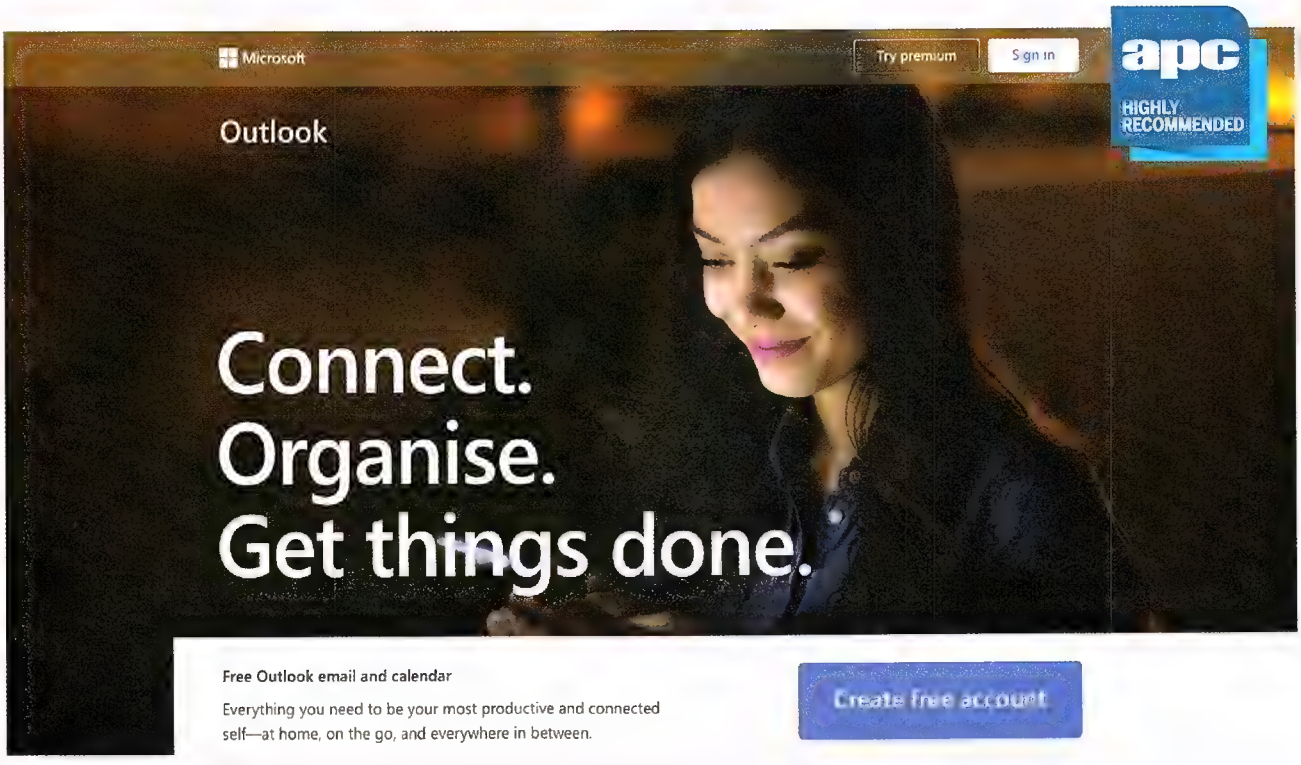
Reflecting on Google's volte-face for this article, I feel genuinely aggrieved at being hoodwinked by Google's promise of forever free storage. I am now so hooked on its services that I essentially can't leave. As a result, I have to use the Unattach app (unattach.app) to annually strip out the larger attachments and back them up to my NAS. Google One, the company's storage hub, will sort and present the largest emails in your inbox, but you have to delete the entire email – you can't strip out the files and keep the original message.

If storage is your main priority, another alternative is Yahoo Mail, which offers a huge 1TB of free storage per account. Yahoo has an excellent email import feature that would make migrating easier, but I can never quite bring myself to complete the switch as all my other online accounts are linked to my Gmail address.

Meanwhile, Outlook comes with the same 15GB of free storage for



The way Gmail organises and presents emails is the standard when it comes to web interfaces.



Outlook's strengths include easy deletion of older emails and seeing attachments in one place.

users. However, it is better at allowing you to save space, as you can delete items from your inbox that are greater than three, six, or 12 months old with just a couple of clicks. You can't strip out attachments, but Outlook has a "Files" tab that allows you to see all the photos and documents from your emails in thumbnail view. If you want to upgrade your storage in Outlook there's only one way to do it, and that's to pay for Microsoft 365, which is $10 per month and bags you 50GB of space. That's terrible compared with Google's 100GB for $1.99 per month, but it's an apples-to-oranges comparison, as Microsoft 365 also gets you 1TB of OneDrive storage, the Office suite of apps, an ad-free Outlook experience, premium support, and quite a bit more. True value is offered by Microsoft 365 Family, which is $13 per month and covers up to six people. Again, both offerings pale in comparison to Yahoo and its free 1TB storage.

Fast and fuss-free

If you're in the Microsoft ecosystem with Windows or Office, then 365 is especially worth paying for, particularly OneDrive syncing in Windows. Likewise, the Mail app in Windows is set up by default with your Outlook address and is a fast and fuss-free way of managing all your email accounts. The Outlook Windows app is also available if you need more features, such as the ability to read your emails aloud. The Outlook mobile app (Android and iOS) is well-designed, making it easy to manage all your accounts from one place. We like the ability to add your storage accounts in Outlook, including OneDrive, Box, Dropbox, and even Google Drive, and access them to send attachments from within the app or website.

On mobile devices though, particularly Android, Gmail's app has the upper hand. You can email and video chat from within the same app, and if your company runs on Google, you'll also see Chat and Spaces along the bottom navigation. There's no Gmail app for Windows, but you can install Google Drive to keep your files synced across devices. The Gmail web interface is also powerful without feeling overwhelming, with a slick design housing loads of useful features.

In this always-connected world, the web interface is where most people interact with their email, and this is where Google pulls away from Microsoft. Google's interface is nicer to look at, easier to use, and doesn't feature ads. Important features such as "Send Later" and "Smart Compose" are enabled by default, allowing you to decide to send your email the following day or save time composing standard responses respectively. These features are available on Outlook, but you have to dig in the settings to find "Undo Send" – a delay time that you can apply to every message before it leaves your Outbox. Meanwhile, "Suggested Replies" only applies to responses, not original messages.

While the introduction of the above features has mitigated the need for add-ons in Gmail, they're still there if you want to play around. The best ones allow you to integrate other applications such as Zoom, Todoist, and Dropbox. We particularly like Inbox When Ready, which hides the inbox when you log in, so you can focus on sending that important message without being distracted by unread emails. Outlook has lots of useful add-ins to do things like strip attachments from emails while keeping the original message, but they're for the app, not the web interface.

Over the last few years, Gmail has gotten worse thanks to its reduced free storage policy, while Outlook has improved its mobile apps and Windows integration. However, Gmail remains the top dog, thanks to its beautiful design, wealth of features, and integration into the wider Google suite. While that 15GB storage might be a constraint over time, it's still the best way for most people to manage their emails.

Gmail Beautiful interface, no ads, Send Later and Smart Compose features, wealth of add-ons. But only 15GB free storage limit and no Windows app.
Guy Cocker

★★★★½

Outlook Great apps for PC and mobile, thumbnail view for attachments, lots of Outlook app add-ins .
Guy Cocker

★★★★☆

TECHNOTES

Gadgets

Lovely little things

❶ AUDIO-TECHNICA SOUND BURGER

The fast food version of record playing is almost as portable as Spotify.

US$199 | audio-technica.com

If you enjoyed rocking out to vinyl in the early 80s then there's a good chance you would have come across Audio Technica's portable record player, the Sound Burger. The technology was discontinued years ago, but it is still a revered piece of tech among today's dedicated vintage crate diggers... and Audio Technica has decided to revive it for the company's 60th Birthday. While the new unit borrows all its style from the device that took on the BoomBox and Sony's Walkman, it's been updated with modern utilities like Bluetooth 5.2 connectivity and a 12 hour rechargeable battery.

❷ SOUNDBOKS GO

This unit has big-speaker-energy in a portable Bluetooth package.

$1,099 | soundboks.com.au

Soundboks is a new Danish speaker company that specialises in making more portable and simplified high-volume speakers for when you need enough sound to please a crowd. The Soundboks Go is the latest instalment of this mission offering a briefcase sized boombox that can reach a respectable 121 dB for up to 10 hours on a single charge at full volume. The 99.84Wh battery just creeps under the legal limit for planes and if you drop the volume to 50% (100ish dB) it'll last for up to 40h according to the company.

❸ ONYX BOOX NOTE AIR2 PLUS

A book, notepad, newspaper and Android tablet all in one.

From $480 | shop.boox.com/en-au

If you're not too attached to either a Kindle or Kobo and you like the idea of a responsive, Android-based e-reader that makes it easy to read books at night... then the new Onyx Boox Note Air 2 Plus is an excellent option. Both Kobo and Kindle have solid Android applications that are easy to use and are translated into e-ink by this clever tablet to make the reading experience indistinguishable from your usual e-reader scenario. The Note Air2 Plus comes with a stylus and a proper tablet processor so you can run your favourite drawing, notetaking and media apps to make it a multi-purpose long-form news reader and notepad.

4 MICROSOFT AUDIO DOCK

A clutter free desktop dock for people who care about web conferencing.

$459 | microsoft.com/en-au

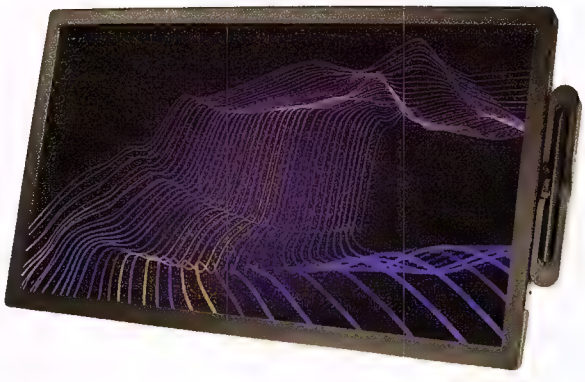
It's still pretty common to get computer monitors that don't include speakers... and you've got Buckley's of finding one that you want with a microphone for web calls. The Microsoft Audio Dock is designed specifically to meet this market gap. The Microsoft Audio Dock allows you to charge your laptop and push a video feed to a connected monitor with one simple USB-C connection, but it's also got two voice-isolating microphones and a set of omnidirectional speakers that'll offer an upgrade to your laptop's stock web-chat setup. There's no Ethernet connectivity, but you'll get ample other interface options and some neat Microsoft Teams integration for those that use it.

5 WACOM CINTIQ PRO 27

Add even more colour to your digital sketchpad.

$5,499 | estore.wacom.com/en-AU

Wacom has long been an important player in the digital designer space and the Cintiq Pro 27 is looking to keep up this tradition with a new, highly customisable stylus and impressive display. The Wacom Pro Pen 3 offers various grip, tip and weight customisations to compliment the 8,192 levels of pressure sensitivity, zero latency input and parallax-less precision pointer. This pairs with the 27-inch 4K display, offering 10-bit AdobeRGB and DCI-P3 colour capabilities, 120Hz refresh rate, sub 10ms response rate, 400 nit typical brightness and a VESA mount system to allow you to use it with your favourite ergonomic stand.

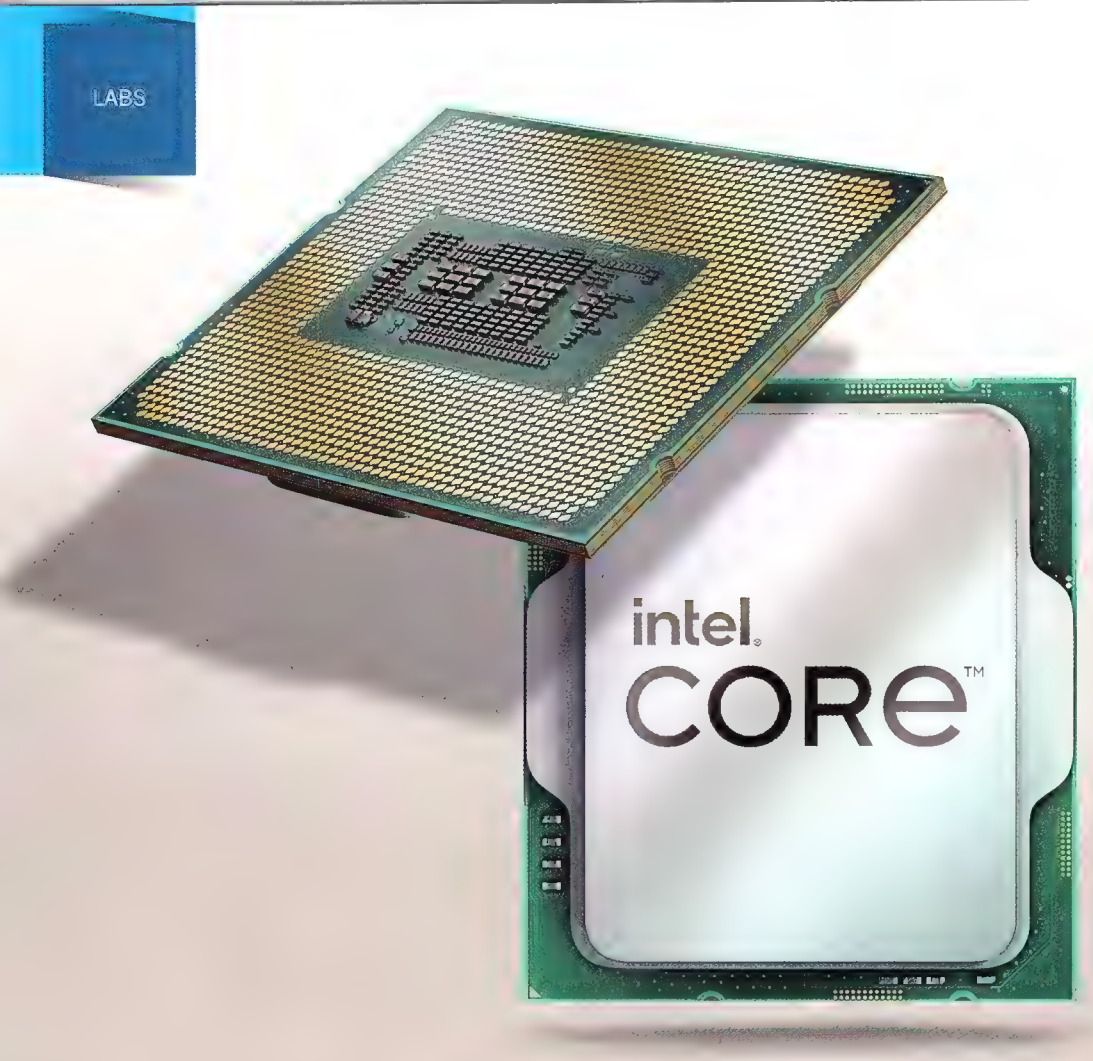


6 SUUNTO 9 PEAK PRO

Take your extreme sports up a notch.

$959 | suunto.com/en-au

Suunto has long been a formidable force in the elite athlete realm of smartwatches and the new Suunto 9 Peak Pro is attempting to take this reputation to new heights. The smartwatch is one of the longest lasting smartwatches on the market with over 40 hours of GPS tracking or 21 days of standard battery life. This allows you the convenience to tackle and track up to 95 different sports in a wide range of challenging environments. There's also a thorough list of MIL-STD-810H benchmarks that the design surpassed to make it 100m waterproof and resistant to drops, high pressure, extreme temperature, corrosion and ingress, so you can take it anywhere.



COVER FEATURE

Intel 13th Generation Core Processors

Intel rises to meet AMD's challenge, as Chris Szewczyk benches up a storm of data and opinions from the Labs.

Christmas came early for PC enthusiasts this year. Just a few weeks after AMD launched its Ryzen 7000 series processors, now Intel fights back with its 13th Generation counterpunch. The range – codenamed Raptor Lake, is accompanied by Z790 motherboards, which continue the use of the LGA 1700 socket. Notably for upgraders, this means that moving to a 13th Gen processor can be a cost effective one, as you can drop one into a Z690 or B660 motherboard after a BIOS update.

The product lineup is nominally the same as that of the 12th Generation range. The 'Core' branding remains the same, with i9, i7, i5 and i3 models. The 'K' overclockable 125W models are launching first. There are also F models, which denotes a lack of integrated graphics. Future non-K models with a 65W TDP will follow, including i5 and i3 models targeting the mainstream market.

13th gen architecture

13th Gen processors can be thought of as an evolutionary upgrade over the well-received 12th Generation Alder Lake range. They include monolithic dies, built on the same Intel 7 manufacturing process and retain the hybrid core architecture. There are two different types of cores: The performance optimised P cores and efficiency optimised E cores. 13th Gen P core counts remain the same relative to their 12th Gen counterparts, while E core counts have increased.

The P cores, codenamed Raptor Cove, feature higher IPC thanks partly to an increase in L2 cache size from 1.25MB to 2MB per core. The Gracemont E cores receive a cache increase too, with 4MB of L2 cache per E core cluster, up from 2MB previously. L3 cache size has also increased, up to a maximum of 36MB.

Intel has done more than just increase cache size. Raptor Lake natively supports DDR5-5600 memory, though unofficially it's capable of much higher speeds. This, along with improved prefetcher and Thread Director enhancements also add performance. The latter is Intel's hardware level scheduler, which helps the OS dynamically assign tasks to the most appropriate core type.

Performance

While these improvements are welcome, they are essentially tweaks to the Alder Lake design, and while that's a good foundation to start with, most of Raptor Lake's performance gains come from clock speed and E core count increases. Intel says electrical design tweaks and channel mobility have allowed it to increase clocks dramatically, by up to 600MHz in the case of the 13900K's P cores.

Intel claims the architectural improvements, clock speed and core count increase combine to deliver up to a 15 percent IPC increase, and up to a huge 41 percent improvement in multi-threaded performance.

Power consumption hasn't been a strong point of Intel's processors over the last few generations, and it increases again here. The base PL1 TDP of the Core i9-13900K and Core i5-13600K remains at 125W, while the maximum turbo power, or PL2 increases to 253W for the 13900K and 181W for the 13600K, an increase of 12W and 31W over their 12th Gen predecessors. The Ryzen 9 7950X reaches up to 230W at its maximum, so while the power consumption gap between AMD and Intel has closed up, it still presents challenges to coolers. Add to this the likes of a 450W RTX 4090 and there's every chance that you'll need a power supply wattage upgrade to build a high spec 2023 class enthusiast PC.

The new motherboards

Joining 13th Gen Raptor Lake processors are 700 series motherboards, starting with Z790. Z790 is very much an evolution of Z690. The two main differences are an increased PCIe 4.0 lane count and support for an additional USB 3.2 Gen 2x2 20Gbps port. This means Z790 boards are able to support up to five M.2 drives, or alternatively, motherboard manufacturers can use the extra lanes for high bandwidth controllers. Some boards include Thunderbolt 4, USB4 or 10G LAN.

"Intel claims the architectural improvements, clock speed and core count increase combine to deliver up to a 15 percent IPC increase, and up to a huge 41 percent improvement in multi-threaded performance."

Z790 boards generally feature faster memory speed support. Though the memory controller is on the CPU itself, Z790 boards feature second-generation electrical designs, and the tips and tricks that board makers learned have been incorporated into Z790 designs. They also feature typically strong VRM designs, which is important to support the 13th Gen's higher turbo power limits.

Importantly, WiFi 6E and 2.5G LAN are trickling down to more affordable price points. And speaking of price points, the prices of Z790 boards look promising compared to the expense of X670E boards. Score one to Intel! and upcoming B760 boards will be even cheaper. They're set to be released alongside the non-K SKUs around CES 2023.

Z790, like Z690, supports PCI Express 5.0, but due to the limited PCIe 5.0 lane count of 13th Gen CPUs, Z790 boards don't have dedicated lanes for a next gen M.2 drive. Raptor Lake supports up to 16 PCIe 5.0 lanes, which would usually be allocated to the primary slot for a GPU, but manufacturers are free to include PCIe 5.0 M.2 slots at the expense of the primary slot. This means you'll get either one x16 expansion slot, two x8 slots or most importantly, one x8 slot and up to two PCIe 5.0 x4 M.2 slots. An 8x GPU slot doesn't mean a lot in the real world, but it may well do in the years ahead, and it's a weakness compared to the full 16x and 4x native configuration of competing AMD X670E boards.

Finally, some testing notes. We initially noted a lot of variation in motherboard benchmarks due to free-for-all turbo and power implementations. To level the playing field, for all motherboard benchmarks, our 13900K CPU was set to Intel's default power limits. For comparative purposes, we included a set of fully unlocked power results too. You can see the difference this makes on the benchmark results page.

One last thing. We used an RTX 3080 Ti for all testing. Time limitations prevented us from retesting all motherboards and CPUs with our RTX 4090, however, it will be included in our new reference testing platform from now on.

Read on as we take Intel's 13900K and 13600K CPUs for a spin, as well as a look at Z790 boards covering a variety of price points. Is Intel back on the top step? Let's see, shall we?

INTEL 13TH GENERATION CORE PROCESSORS: THE HIGH- AND MID-RANGE HEROES REVIEWED

"In simple terms the 13600K can be considered an upgraded 12600K. It contains six performance cores and eight efficient cores for a total of 20 threads."

CPU

Intel Core i5-13600K

The star of the 13th Generation range.

■ $569 | www.intel.com

Intel's i5-12600K earned our maximum 5/5 score when it launched last year. Its excellent blend of performance, respectable power consumption and value for money made it a superb all-round chip. If we examine the spec of the i5-13600K, it looks like it's even better.

In simple terms the 13600K can be considered an upgraded 12600K. It contains six performance cores and eight efficient cores for a total of 20 threads. The price has risen to $569, up from the 12600K's $499 launch price, but that's not a bad increase at all given the inflation over the last year, on top of the huge dip in the value of the Australian dollar. When compared to the launch price of AMD's competing Ryzen 7700X at $689, the 13600K is a very compelling option.

The 13600K's P and E cores actually drop in base clock speed compared to the 12600K, down by 200MHz, but that matters little in real world testing, where operating clocks are almost always higher. The P cores can boost up to 5.1GHz, that's quite a drop over the maximum 5.8GHz of the 13900K, but it's a 200MHz increase over the 12600K. The clock speed increases require a power consumption bump. The 13600K retains the base 125W PL1 TDP of all 13th Gen K CPUs, but sees a rise in maximum PL2 power, increasing to 181W, compared to 150W for the 12600K.

The 13600K of course receives the Raptor Lake cache upgrades, with 20MB of L2 cache and 24MB of L3 cache, and much like the 12900K, the Intel UHD770 graphics is mostly unchanged apart from a small maximum clock speed increase. Notably for upgraders, the 13600K, like the other 13th Gen models, retains both DDR5 and DDR4 memory support and compatibility with Z690 motherboards. This means 12th Gen owners have a very cost-effective upgrade path in contrast to the purchase of an AMD system, which requires a new AM5 motherboard and DDR5 memory as well.

The 13600K delivers excellent performance, generally beating out the 7700X. The additional E-cores deliver a healthy multithreading boost over the 12600K and its gaming performance is stellar. It offers almost all of the gaming performance of the 13900K at around half the price, allowing you to save money you can put towards a new GPU, which will really boost your FPS.

Perhaps the only downside is the increase in power consumption over the 12600K. Under a sustained all core load, the 13600K system consumed a peak of 278W, that's 40W more than a 7700X system and 56W more than a 12600K system. Compared to the 391W of a stock 13900K system though, 278W is downright thrifty. A good air cooler or 240mm AIO won't have a problem keeping a 13600K cool.

The 13600K is the best all-round CPU on the market right now. Its gaming performance is outstanding, it's good at heavily threaded tasks without going too crazy on power consumption and it offers good value for money. AMD's 7700X remains competitive, but it costs more and loses some of the power efficiency advantage the Ryzen 5000 series had. If you're after a CPU that can do it all, and you don't need loads of cores for heavily threaded applications, the 13600K can't be beaten.

The 12600K was an excellent CPU, but the stellar all-round performance of the 13600K is even better.

★★★★★

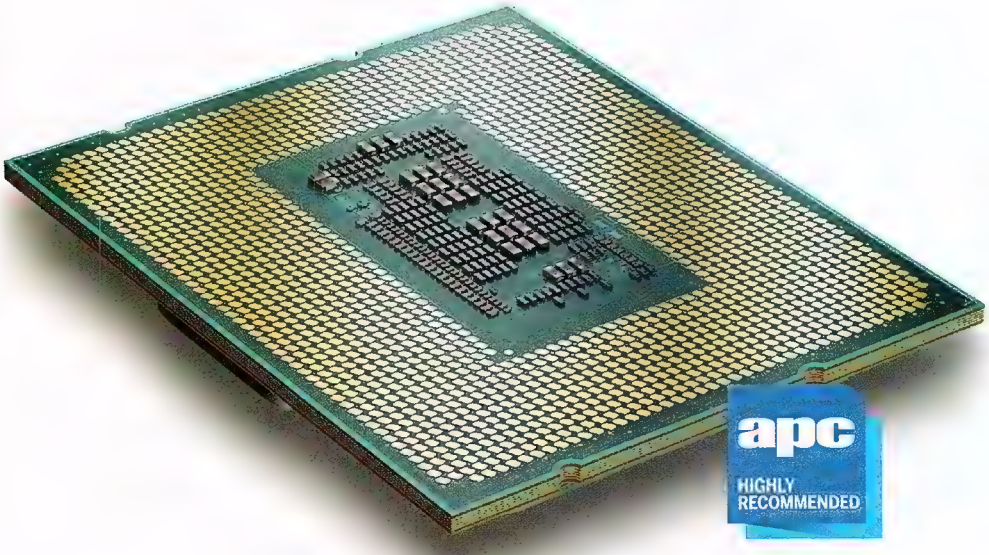
■ Intel Core i5-13600K; LGA 1700 socket; 6 P cores + 8 E cores, 20 threads; P core Base/Max Clock Speed 3.5/5.1GHz, E core Base/Max Clock speed 2.6/3.9 GHz; 24MB L3 Cache; 125W Base Power, 181W Maximum Turbo Power.

CPU

Intel Core i9-13900K

Unleash the beast.

■ $1,099 |]www.intel.com



"The 13900K is designed to perform at all costs. The extra E cores and higher clock speeds give it the edge it needs to take the all-round performance crown."

If you're after a CPU that delivers performance above all other considerations, the 13900K is the 13th Gen model for you. It's more than just an overclocked 12900K. It gains an additional eight E-cores giving it a total of 8 P cores and 16 E cores for a total of 32 threads, which just happens to match the thread count of AMD's Ryzen 9 7950X.

At $1,099, it's only $30 more than the 12900K's launch price. Considering inflation over the last year, along with the drop in the value of the Aussie dollar, it's relatively better value, and notably, it's cheaper than the price of the AMD's 7950X at $1,139.

Two P cores can boost as high as 5.8GHz while the E cores can boost to 4.3GHz. Under an all core load the P-Cores can reach as high as 5.4GHz. That's amazing, really. The 13900K contains the maximum available 32MB of L2 cache and 36MB of L3 cache. So, it's got more cores, much higher frequencies and more cache than the 12900k.

Other key features include Intel UHD770 graphics and support for DDR5-5600, though it retains compatibility with DDR4 memory too, supporting DDR4-3200 memory. In reality though, all 13th Gen processors will support faster memory, with a new wave of DDR5-7000MHz and higher kits coming to market.

The 13900K is designed to perform at all costs. The extra E cores and higher clock speeds give it the edge it needs to take the all-round performance crown. Its multi-threading performance in particular is excellent. The 13900K finally matches or beats AMD which for a few generations has excelled at heavily threaded tasks.

The higher boost clock speeds give it an edge in gaming and lightly threaded tasks too. Now that Intel's hardware level Thread Director has matured, along with a year of Windows development, the 13th Generation range and 700 series motherboards in general combine into a mature all-round platform.

But there's one area Intel has yet to address, that's if it's even attempting to. Power consumption continues to creep upwards. The PL2 power limit increases to 253W, but when unlocked, that can rise to well over 300W for the CPU alone, and that provides a cooling challenge. Our 360mm AIO cooler wasn't enough to keep the 13900K from hitting 100C and throttling under heavy loads.

With that in mind, unless you have top of the line water cooling or you're fortunate to have a good chip, there's little headroom left for manual overclocking. However, memory overclocking is much better, our chip had no problem hitting DDR5-7000 and surely has some headroom left.

If you're an enthusiast chasing the best performance, the 13900K is the CPU for you, but it comes at a cost in terms of money, power consumption and resulting cooling requirements. Perhaps the biggest competition for the 13900K comes not from AMD, but Intel's own 13700K and 13600K, both of which deliver performance that's almost as good (unless you really require multi core grunt).

12th Gen Alder Lake was Intel's best architecture in many years and the 13900K takes it to the next level, extracting everything from the Intel 7 process. Just make sure you have top spec cooling, otherwise it will throttle, negating its performance advantage.

The 13900K sits on the top step of the desktop CPU podium, though for most users, the spectacular i7 and i5 K models are better buys.

★★★★☆

■ Core i9-13900K; LGA 1700 socket; 8 P-Cores + 16 E-Cores, 32 threads; P-core Base/Max Clock Speed 3.0/5.8GHz, Single E-core Base/Max Clock speed 2.2/4.3GHz; 36MB L3 Cache; 125W Base Power, 253W Maximum Turbo Power.

INTEL Z790 MOTHERBOARDS: Z690 VERSION 2.0?

MOTHERBOARD

Asrock Z790 Steel Legend WiFi

A mid-tier Z790 board without a high-end price.

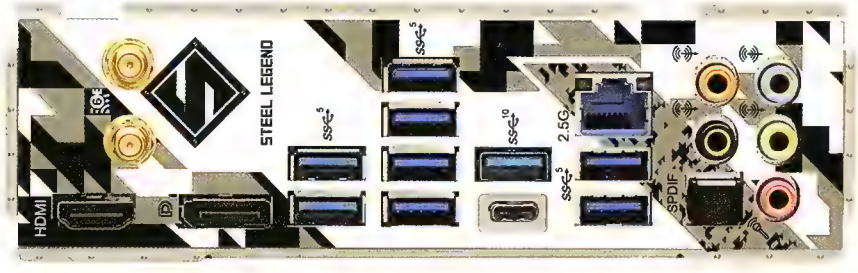
■ $589 | www.asrock.com

Asrock's Z790 Steel Legend may not have the most compelling name ever, but as long as it delivers good value and an attractive feature set, the name matters little. The Z790 Steel Legend is Asrock's mid-tier sub brand, sitting above the PG and Pro ranges, and below the high end Taichi.

Fittingly, the Steel Legend comes with an attractive metallic theme. The heatsinks aren't huge compared to high end boards, but they are perfectly functional. If you love RGB, the Steel Legend has a good amount onboard, even more than some so-called gaming motherboards.

The primary M.2 slot is cooled by a now commonly implemented oversized cooler. Unusually, Asrock has two opposing primary M.2 slots, one of which supports PCIe 5.0 and the other PCIe 4.0. Only one can be used at a time. It's a good solution as either way you'll still benefit from the board's SSD cooling.

The board doesn't have the most powerful VRM you'll ever see. A 16+1+1 solution with 60A stages won't suit the extreme overclockers as much as a high-end board, but for an air or AIO cooled 13900K, it's more than enough, even though this is the kind of board that probably won't be paired with such a CPU.



You still get dual 8-pin power connectors. The cooling is more than adequate, with the heatsinks never feeling hot to the touch, even with a 13900K humming along under a sustained all core load.

The rear I/O offers just about everything you would expect at this price point. 2.5G LAN and WiFi 6E are standard. A pair of USB 3.2 Gen 2 ports (type-A and type-C) are welcome, plus you get another eight Gen 1 ports. The board has a header for a type-C 3.2 Gen 2x2 port. Not bad at all! However, Asrock opted to include an aging Realtek ALC892 audio codec.

The board features notably strong display support, with HDMI 2.1 and DP 1.4 ports at the back, however, the Steel Legend also includes an embedded Display Port header. This would be useful for mounting a side panel display.

Unlike the all new X670 platform, Z790 is an evolution of the now mature Z690, and a lot of its underlying BIOS code is mature. It's not the fastest under all core loans but notably, its gaming performance was generally ahead of the others, though only by a frame or two here or there as usual. We're also pleased with Asrock's BIOS, which seemed impressively stable from our playing with the commonly adjusted settings, including the power and turbo settings.

The Z790 Steel Legend is a step above entry level Z790 boards. It offers an attractive feature set – particularly its M.2 complement. It's hard to fault with the exception of the average audio implementation. Though unless you're an audio purist, it will suffice. Its performance is within the range of the other board tested boards and its silver coloured heatsinks and considerable number of RGB LEDs will appeal to users bored by all black 2022 era designs.

At $589, it's very affordable, especially when compared to almost all mid-range X670/E boards. If you're after a Z790 board with DDR5 support and excellent connectivity options, the Steel Legend is well worth a look.

The Steel Legend is a strong option for users looking for something more than you'd get from entry level Z790.

★★★★☆

■ Asrock Z790 Steel Legend WiFi; LGA1700 socket; 1x PCIe 5.0 M.2, 4x PCIe 4.0 M.2; 8x SATA; Up to 1x USB 3.2 Gen2x2, 2x USB 3.2 Gen 2, 12x USB 3.1 Gen 1, 3x USB 2.0; 1x HDMI 2.1, 1x DP 1.4; Wi-Fi 6E; Realtek 2.5G LAN; Realtek ALC897 7.1 Channel HD Audio; ATX Form Factor.

MOTHERBOARD

Asus ROG Strix Z790-I Gaming WiFi

Big on features – not on size.

■ $899 | www.asus.com

Most Z790 motherboards aren't all that different from their Z690 predecessors. True innovation is relatively rare, but when it comes to mini-ITX boards, some out of the box thinking is required. Asus' ROG Strix Z790-I Gaming WiFi is a perfect example. It's the result of telling the engineers to try to squeeze an ATX feature set into an ITX form factor.

Despite all reasonable efforts, things that take space, like M.2 drives, PCIe slot numbers and heatsinks require compromise, but by every other reasonable measure, the Strix Z790-I solves more than one engineering challenge. First among these is the double stacked M.2 solution, with one PCIe 5.0 and one PCIe 4.0 slot. Next is the 'FPS-II' daughter board which contains two SATA ports, USB 2.0 headers and the front panel header among other things.

Then there's what Asus calls the ROG Strix Hive. It includes the ALC4050 Audio and ESS Sabre DAC audio solution, more USB ports and buttons to control things like auto overclocking and the no-CPU BIOS flashback. There's a programmable button that defaults to a system reset, but can also be used for safe mode and controlling the Aura RGB lighting. All of these things are not trivial to make and go a long way to justifying the steep $899 price tag of the Z790-I.

Back to more worldly motherboard matters, the VRM is a good one for a diminutive board. A 10+1 phase solution with 105A stages is enough for a 13900K, though note you only get a single 8-pin power connector, so it's not one you'd use to push too hard with. The heatsinks are also compact by necessity, yet it includes an embedded tiny fan. Temperatures peaked at 72C, not bad given their tiny size.

It's also worth noting that the socket area is especially cramped, so much so that our test AIO cooler would only fit in one direction.

With a lot of the connectivity included on the external Hive device and FPS-II card, the rear I/O looks a little bare. WiFi 6E and 2.5G are standard and a pair of type-C Thunderbolt 4 ports and a USB 3.2 Gen 2x2 port are real highlights.

The little Strix didn't lose anything in terms of performance. It produced a strong 7-zip result, indicating excellent memory performance, which may be a result of its dual DIMM configuration. The new breed of DDR5-7000+ memory should perform well on this board.

Mini-ITX systems have a dedicated following, and when you see what kinds of features that can be packed into SFF systems with boards like the Asus ROG Strix Z790-I Gaming WiFi, it's no wonder. A compact system with a 13900K, 32GB of RAM and RTX 4090 sounds pretty good, though the words '4090' and 'small form factor' probably don't belong in the same sentence.

At $899 it's a pricey proposition, but then there are plenty of Z790 boards priced over the $1,000 mark, particularly X670E boards. Suddenly $899 seems almost reasonable. Given the additional engineering challenges presented by an ITX board, and the excellent feature set on offer, this little Asus is worth its premium price.

This little pocket rocket crams a lot of features and innovation into its ITX size, though it comes at a price.

★★★★½

■ Asus ROG Strix Z790-I Gaming WiFi; LGA1700 socket; 1x PCIe 5.0 M.2. 1x PCIe 4.0 M.2; 2x SATA; Up to 2x Thunderbolt 4, 2x USB 3.2 Gen2x2, 4x USB 3.2 Gen 2, 3x USB 3.1 Gen 1, 6x USB 2.0; 1x HDMI 2.1; Intel Wi-Fi 6E; Intel 2.5G LAN; Realtek ALC 4050 7.1 Channel HD Audio; Mini-ITX Form Factor.

apc HIGHLY RECOMMENDED

MOTHERBOARD

Gigabyte Z790 Aorus Master

Can a $1,000 board actually be relatively reasonably priced?

■ $1,029 | www.gigabyte.com

Gigabyte's Z790 Aorus Master is the most expensive board we've got in this roundup, and it definitely looks the part. At $1,029 it's not actually overly expensive compared to the X670E alternatives, and its price competitive with the other makers' high end Z790 boards.

The Aorus Master is an extended ATX motherboard, meaning it is wider than usual and care needs to be taken to be sure it fits in your case. Gigabyte has gone for black and grey theme with just a splash of Aorus RGB atop the I/O shield. The heatsinks look and feel fantastic. Gigabyte says they are 'nanocarbon' coated. Thankfully the underlying heatsink retains Gigabyte's excellent fin design, which means more surface area and better cooling.

The Master's VRM is excellent, as you'd expect from a board that's expected to power overclocked 13900K's. a 20+1+2 phase VRM with 105A stages will happily provide juice for ln2 overclockers. Until we see the likes of the Aorus Tachyon or Asus Apex, this is likely to be about as good as it gets, VRM wise. And it runs cool too. With our 13900K set to unlimited power, it peaked at 57 degrees.

Gigabyte opted to include support for a PCIe 5.0 SSD, though like all Z790 boards, it necessitates dropping the primary PCIe slot down to 8x. The primary M.2 slot is cooled by a very large heatsink, and indicators are that it will be needed when hot PCIe 5.0 drives arrive in 2023. There are five M.2 slots in total, with the remaining four supporting PCIe 4.0. The board includes four SATA ports. Six would be more appropriate for a $1,000+ board.

If you need a lot of USB ports, look no further. There are no less than 14 on the back panel alone. There's two 3.2 Gen 2x2 Type-C and a Gen 1 Type-C. Joining these are seven Gen 2 and four Gen 1 ports. Thunderbolt 4 or USB 4 would be nice, but even at this price, you can't have everything compared to a board at $1,500 or more.

The Master includes 10G LAN and Killer Wi-Fi 6E. We love to see 10G and hope it trickles down to cheaper boards in the future. The board includes ALC1220-VB audio which feels like last gen, though it's a strong implementation with Gigabyte's reliable choice of components, including an ESS ES9118 DAC.

At the time of writing, Gigabyte was set to release an 'instant 6GHz' option for 13900K owners. That will be interesting to see in action, though you'll need top spec cooling or low ambient temperatures for that to be successful.

The Z790 Aorus Master comes with a good, but not excellent spec, as do many other boards in this price range. It depends on how you weigh certain features. The Aorus has 10G LAN, but omits USB 4 or Thunderbolt and along with the use of ALC1220, it seems like more of a Z690 generation board. In fact, the toughest competition for the Z790 Aorus Master might be the Z690 Aorus Master. It's a couple of hundred dollars cheaper and apart from the PCIe 5.0 M.2 slot, it seems very similar.

But in the end, the Z790 Master is a strong one and unless you need a specific feature that's exclusive to flagship boards, it doesn't disappoint.

The Z790 Aorus Master is a high quality offering, but it feels like a Z690 V2.0 board rather than something that's truly next gen.

★★★★☆

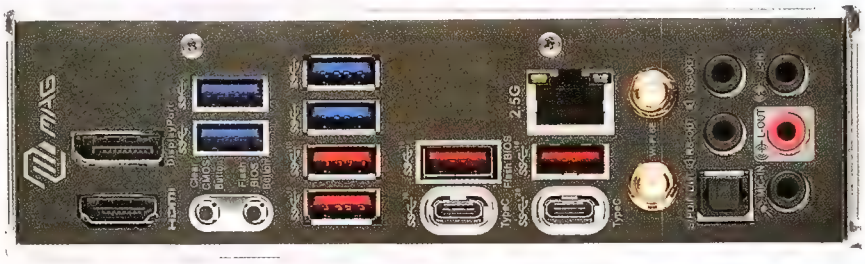
■ Gigabyte Z790 Aorus Master; LGA1700 socket; 1x PCIe 5.0 M.2, 4x PCIe 4.0 M.2; 4x SATA; Up to 3x USB 3.2 Gen2x2, 8x USB 3.2 Gen 2, 8x USB 3.1 Gen 1, 4x USB 2.0; 1x DP 1.2 Killer AX1690 Wi-Fi 6E; Marvell AQtion 10G LAN; Realtek ALC 1220-VB 7.1 Channel HD Audio; E-ATX Form Factor.

MOTHERBOARD

MSI MAG Z790 Tomahawk WiFi DDR4

One last hurrah for DDR4.

■ $549 | www.msi.com



When Intel announced that Z690 would support DDR4, many users breathed a sigh of relief. At the height of the pandemic supply woes, DDR5 was simply unobtainable and using your DDR4 was an excellent way to board the 12th Gen train. Given that 12th and 13th Gen share the same socket, it's no surprise to see Z790 continuing to support DDR4, though it's most likely the end of the road for DDR4.

MSI offers two versions of its Z790 Tomahawk, and we have the DDR4 supporting version on hand. MSI's Tomahawk boards usually earn praise for their combination of price and feature set, including stronger VRM designs than those of entry level boards. At a glance, the MSI looks like another solid mid-range contender, and at $549 it offers a lot for the money.

It's hard to go wrong with an all-black design. MSI has chosen to include four PCIe 4.0 M.2, leaving all of the CPU's 16 PCIe 5.0 lanes for the primary expansion slot. All four M.2 slots have heatsinks, though the primary slot is a simple one compared to those designed for cooling future PCIe 5.0 drives.

The VRM is a real highlight. It stands up well compared to boards at hundreds of dollars more. It's a 16+1+1 configuration with 90A stages. You can happily run an overclocked 13900K and rest assured knowing your cooling will give out well before the VRM reaches its limits. However the heatsinks don't have the surface area befitting a VRM of this spec. In our testing, the VRM reached a peak of 69 degrees while looping Cinebench. Not great, not terrible, but a little more surface area (fins would be even better) would definitely benefit.

The rear I/O is impressive, with a total of ten USB ports, topped by USB 3.2 Gen 2x2 and Gen 2 Type-C ports. Add to that another four Gen 2 ports and four Gen 1 ports. There's 2.5G LAN and WiFi 6E, A full set of audio ports powered by a Realtek ALC4080 codec, CMOS and BIOS flash buttons and finally HDMI 2.1 and DP 1.4 ports. That's a very well-rounded set of options, especially at this price where USB4 or Thunderbolt 4 is not expected.

The MSI, like most Z790 boards, seemed to be mature, with fast boots and a lag free BIOS. As usual, MSI's BIOS layout is excellent, and has hardly changed over the years since the introduction of UEFI.

You lose a little performance with DDR4 compared to DDR5, though it's app specific. Handbrake, for example, showed a large deficit, yet it loses little in gaming. Unless you have DDR4 already to use with the Tomahawk, it's worth saving a little for DDR5. DDR4 is now at the end of its life and it makes little sense to buy new DDR4 for a new system. MSI has a Z790 Tomahawk DDR5 as an alternative.

MSI's Z790 Tomahawk DDR4 offers tremendous bang for your buck, with a well-rounded feature set, but only if you have a set of DDR4 already. It lacks PCIe 5.0 M.2, so the Asrock is an alternative if you plan to upgrade in the future. As a solid, feature rich board with a strong VRM for a high-end CPU, the Z790 Tomahawk is another entry that deserves to sit alongside the highly regarded Tomahawks of past generations.

If you must have a DDR4 board for your 13th Gen system, the MSI Z790 Tomahawk delivers a lot of board for your buck.

★★★★☆

■ MSI MAG Z790 Tomahawk WiFi DDR4; LGA1700 socket; 4x PCIe 4.0 M.2; 7x SATA; Up to 1x USB 3.2 Gen2x2, 6x USB 3.2 Gen 2, 6x USB 3.1 Gen 1, 4x USB 2.0; Intel Wi-Fi 6E; Intel 2.5G LAN; Realtek ALC 4080 7.1 Channel HD Audio; ATX Form Factor.

INTEL 13TH GENERATION CORE PROCESSORS BENCHARK RESULTS

	AMD Ryzen 9 7950X	AMD Ryzen 7 7700X	AMD Ryzen 7 5800X	Intel Core i9-13900K (default)	Intel Core i9-13900K (unlimited power)	Intel Core i5-13600K	Intel Core i9-12900K	Intel Core i5-12600K	Intel Core i9-11900K
Handbrake 1.5 - Video conversion 4K to 1080p FPS	84.7	67.3	53.7	91.7	[illegible]	78.6	79.6	64.1	51.9
Cinebench R23 - Rendering - Multi thread Score	38,384	19,810	15,795	35,508	[illegible]	23,934	27,503	17,319	15,352
Cinebench R23 - Rendering - Single thread Score	2,050	2,000	1,603	2,179	[illegible]	2,008	2,022	1,873	1,622
Blender 3.2 Whitelands - Render Time (seconds) Lower is better	[illegible]	798	988	436	408	699	607	969	1042
7Zip 22.01 - File Compression - Billion Instructions per second	227.99	129.02	101.22	204.81	205.33	132.68	138.97	95.31	85.83
CPU-Z - Multi Thread Score	15,954	8,060	6,825	16,966	[illegible]	9,945	11,427	6,961	6,525
CPU-Z - Single Thread Score	802	776	674	902	[illegible]	829	824	759	676
Peak System Power Consumption - Wall Draw (watts)	352	238	[illegible]	391	445	278	341	222	318
PCMark 10 - Extended Score	13,695	12,939	11,885	13,217	13,484	11,750	12,182	11,159	10,717
3DMark Storage Benchmark - score	3,318	3,367	3,393	3,482	[illegible]	3,298	3,469	3,474	3,202
3DMark TimeSpy Extreme - Overall score	10,579	9,598	9,189	10,562	[illegible]	9,944	10,158	9,246	9,190
3DMark TimeSpy Extreme - CPU Score	13,053	6,814	5,685	12,328	[illegible]	7,999	9,269	5,845	5,892
Civilization VI - 1080p, Ultra, DX12, Avg FPS	296	296	278	[illegible]	304	297	297	294	234
Civilization VI - 1080p, Ultra, DX12, Min FPS	226	214	219	[illegible]	230	232	223	203	198
Civilization VI - 1080p, Ultra, DX12, AI Turn Time	[illegible]	6.11	6.34	5.96	[illegible]	5.92	6.33	6.54	6.52
Ghost Recon: Breakpoint - 1080p, Low, Avg FPS	238	233	221	249	[illegible]	235	234	222	198
Metro: Exodus Enhanced Edition - 1080p, Ultra, DX12, Avg FPS	133.2	136.0	127.0	133.5	[illegible]	133.7	129.7	129.4	117.7
Metro: Exodus Enhanced Edition - 1080p, Ultra, DX12, Min FPS	63.2	70.0	75.6	72.5	[illegible]	70.1	68.6	66.9	69.4
F1 2021 - 1080p, ultra high Preset, Avg FPS	194	196	188	[illegible]	205	195	198	202	178

CONCLUSION INTEL'S NEW WINNING WAYS

And with that, Intel returns to the top step of the podium. But for how long? The world of PC hardware can be fluid. A price drop can change everything, and let's not forget, people's choice of hardware can come down to just more than a few benchmarks and a list of specs.

The first wave of 13th Gen Raptor Lake CPUs are exciting from an enthusiast point of view, but the high-volume models are yet to come. The 65W locked multiplier models may throw up some surprises. The likes of an i5-13500 or i5-13400 should carry the excellent traits of the 13600K, but in a cheaper and lower power form, albeit with proportionally lower clock speeds. They're rumoured to include E-cores for the first time.

If you consider the upcoming i5-13400, which should include four E-cores, giving it 20 threads, on paper it will be a mega all-round CPU. If it settles around the $300 mark, AMD is going to have to come up with something special if it's to compete. It's hard to see the 7600X competing even if it drops to price parity. Intel's E core strategy is a good one. It's successfully drawn level, if not ahead of the multi-threading prowess of AMD's competitors at every price point.

AMD's challengers remain strong offerings, and though we might choose an Intel CPU like the 13600K at its release price point, that can change. Should AMD drop the price of its 7700X competitor, the narrative could change. One can rightfully argue that although it's expensive, the AM5 platform has a long life ahead of it, unlike LGA 1700, which is due to be

INTEL Z790 MOTHERBOARDS BENCHARK RESULTS

	Asrock Z790 Steel Legend WiFi	Asus ROG Strix Z790-I Gaming WiFi	Gigabyte Z790 Aorus Master	MSI Z790 Tomahawk WiFi DDR4
Handbrake 1.5 - Video conversion 4K to 1080p FPS	89.2	92.7	91.7	80.3
Cinebench R23 - Rendering - Multi thread Score	36,541	35,709	35,508	35,508
Cinebench R23 - Rendering - Single thread Score	2,112	2,179	2,179	2,240
Blender 3.2 Whitelands - Render Time (seconds) Lower is better	440	435	436	440
7Zip 22.01 - File Compression - Billion Instructions per second	200.51	208.31	204.81	146.51
CPU-Z - Multi Thread Score	16,576	16,831	16,966	17,007
CPU-Z - Single Thread Score	918	893	902	905
PCMark 10 - Extended Score	12,947	13,247	13,217	13,107
3DMark Storage Benchmark - score	3,312	3,483	3,482	3,365
3DMark TimeSpy Extreme - Overall score	10,675	10,617	10,562	10,510
3DMark TimeSpy Extreme - CPU Score	12,816	12,314	12,328	11,650
Civilization VI - 1080p, Ultra, DX12, Avg FPS	301	295	305	296
Civilization VI - 1080p, Ultra, DX12, Min FPS	218	220	231	227
Civilization VI - 1080p, Ultra, DX12, AI Turn Time	6.02	6.09	5.96	5.96
Ghost Recon: Breakpoint - 1080p, Low, Avg FPS	243	241	249	236
Metro: Exodus Enhanced Edition - 1080p, Ultra, DX12, Avg FPS	133.2	130.8	133.5	132.7
Metro: Exodus Enhanced Edition - 1080p, Ultra, DX12, Min FPS	71.1	69.7	72.5	71.4
F1 2021 - 1080p, Ultra High Preset, Avg FPS	199	203	205	195

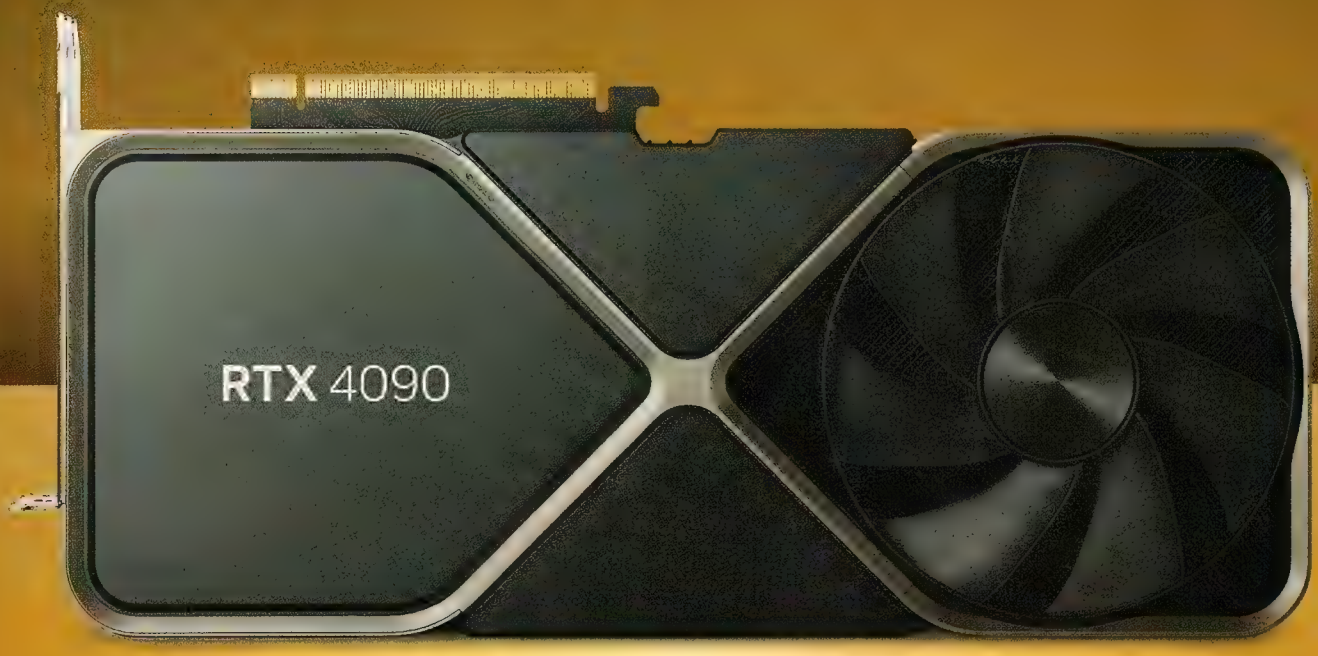
superseded by a new socket.

It isn't all smooth sailing for Intel though. Intel continues to push power consumption to ever higher levels. The 13900K already stresses a 360mm AIO to its limits, and that's the best mainstream cooling you can get. Where can it go from here? Let's hope 14th Generation Meteor Lake processors don't go over the power consumption and temperature cliff.

That's a year off though. In the short term, AMD is expected to launch a 7000 X3D with stacked V-cache. If they're anything like the 5800X3D, we can expect AMD to seriously challenge for the gaming crown, at the very least. But then there's rumours of a 13900KS with 6GHz clocks. Six Gigahertz! Who needs UFC when you've got AMD and Intel duking it out?

At the end of the day, you can't really go wrong, no matter what CPU and motherboard you choose. A competitive AMD and Intel is a win for all of us. It forces both companies to innovate, or lower prices, or both. A 13th Gen for a high-end gaming system sounds good, as does a rendering monster 7950X system. Perhaps you're after something a little worldlier? A 13600K delivers awesome performance at a good price. Alternatively, a 7600X system based on the AM5 platform delivers a far superior upgrade path, even if it's a costly path to go down right now.

When you look at the technology and performance on offer from the best CPUs, and particularly GPUs, it's been an exciting upgrade season. And there's even more to come. ■



Nvidia GeForce RTX 4090

Supreme graphics power.

Nvidia's GeForce RTX 40 series is here! The flagship RTX 4090 is the first card to feature the new Ada Lovelace architecture. The AD102 GPU at the heart of the card delivers a massive generational performance uplift, improved ray tracing, AI capabilities, and it introduces new and upgraded technologies including the dramatically improved DLSS 3.

Ada Lovelace is named after a 19th century English mathematician and computer programming pioneer. The high-end RTX 4090 GPU is known as AD102. The AD103 (RTX 4080 16GB) and the card previously known as the RTX 4080 12GB with the AD104 GPU will follow at a later date. The latter is sure to end up being rebranded as the RTX 4070 or 4070 Ti.

Under the hood

The AD102 GPU packs in an incredible 76.3 billion transistors into its 608mm² die. Given all of the extra cache and shader power, that's actually smaller than the GA102 of the RTX 3090 cards. The reason for that is the shift from 8nm to TSMC's 4nm process. It's a big and expensive GPU to produce, and sadly that translates into a high price for Australian customers, with a base launch price of a steep AU$2,949, and many cards selling for well over $3,000. Even during the height of the crypto currency mining craze, that would have been a high price.

The RTX 4090 uses a harvested version of the AD102 GPU. It contains 16,384 cores (out of a maximum 18,432), with 512 Tensor cores, 128 RT cores, 512 texture mapping units and 176 render output units. This leaves Nvidia free to release an RTX 4090 Ti or maybe even a Titan at some point in the future. Additionally, Nvidia has drastically increased the cache sizes across the range. The 4090 packs in 72MB of L2 cache compared to just 6MB of the 3090 Ti. Nfinity cache, anyone?

The cards come with 24GB of 21Gbps GDDR6X memory. With its 384-bit bus, it delivers up to 1,008GB/s of bandwidth. That's the same as the outgoing RTX 3090 Ti. RTX 40 cards come with a PCIe 4.0 x16 interface, as will AMD's RDNA 3 cards.

Tricky tech

Ray tracing has gone from a curiosity to niche to being important, and now it's well on its way to being an essential component of modern-day gaming.

Ada Lovelace incorporates Nvidia's 3rd generation RTX technology. The RT cores are much more powerful, incorporating a brand-new micro-mesh engine, which helps to reduce the performance penalty associated with ray tracing. The RT cores also include what Nvidia calls the Opacity Micromap Engine, which aims to break up the workloads of shader-based computations into more manageable workloads.

The new Tensor cores are used for matrix multiplications and are critical to AI applications, including DLSS 3, which is exclusive to RTX 40 cards. While DLSS 3 is outwardly similar to DLSS 2, its ability to generate frames without burdening the graphics pipeline delivers dramatic performance improvements with minimal visual quality loss. Check out our DLSS 3 deep dive on page 51 for more on that fascinating tech.

An often-overlooked feature is the video engine. RTX 40 cards receive some welcome updates. The eight generation NVENC supports AV1 encode and decode and HEVC support up to 8k at 60Hz or four concurrent 4K streams at 60Hz. Streamers using software like OBS or content creation software such as DaVinci Resolve will appreciate its features, and there are not one but two encoders on the 4090.

So, the 4090 packs in loads more cores, sub processors and cache, but that's not all. Clock speeds are much higher for the RTX 40 generation. The RTX 4090 is able to reach above 2,700MHz. Compare that to boost clocks in the 1800MHz range for a 3090 and it's clear to see where a lot of the 4090's performance gain comes from.

Maximum power

For all the pre-launch rumour mongering and talks of 600W+ TDP's, the RTX 4090 comes in at the same 450W of the 3090 Ti. That's still historically high for a graphics card, but factoring in performance per watt, Nvidia has made an incredible leap forward. In fact, Nvidia could have brought the 4090's power consumption down by double digit percentages and still maintained almost all of its performance. There might not be much overclocking headroom on the 4090, but there's a lot of room for experimenting with undervolting.

On the topic of power, all RTX 4090 cards come with the new 16-pin 12VHPWR PCIe 5.0 power connector. It's capable of providing a staggering 600W of power. These connectors are not yet widely supported by power supply manufacturers, so Nvidia and its partners include adapters with up to four 8-pin power connectors. At the time of writing, questionable reliability of the 16-pin power adapters was coming to light. The best advice is to keep the connector as straight as possible, by not pressing it or bending it against a case. Also make sure the connector is inserted all the way.

It also seems like Nvidia missed a trick by not including DP 2.1. While 8K monitors aren't going to take much market share in 2023 – if ever, any gamer who does use one is likely to be using a high end 4090 class card. Is it a glaring omission? You be the judge. 240Hz at 4K or 60Hz at 8K with DP 1.4 should be sufficient for most.

> "Ray tracing has gone from a curiosity to niche to being important, and now it's well on its way to being an essential component of modern-day gaming."

To the Labs!

We have two cards on hand for review. The first is Nvidia's RTX 4090 Founders Edition, and the second is the Asus ROG Strix RTX 4090 OC Edition. The cards are big. Very big. So much so that fitting them into compact PC cases is often simply impossible. In fact, even some very large cases may struggle to accommodate the sheer dimensions of larger cards like the Aorus Master or Asus Strix. If you're hoping to plug one into your existing case, please do check that it will fit before shelling out your hard earned money.

We encourage you to read our RTX 4090 reviews on the following pages, but if you don't, let it be known that either of these cards – along with any other RTX 4090 – are fast, big, expensive, unapologetically powerful, and oh so desirable.

Chris Szewczyk

Nvidia GeForce RTX 4090 Founders Edition

Classy performance.

■ $2,959 | www.nvidia.com

Nvidia's Founders Edition cards can no longer be considered generic variants. If you take a glance at the RTX 4090 Founders Edition, it really looks every bit a premium piece of engineering. In fact, I'd go as far as saying there's almost a bit of an Apple vibe to it. Its metallic shroud includes a subtle backlit GeForce logo. It looks fantastic.

FE cards have grown in recent generations. The RTX 4090 is a genuine triple slot card. It incorporates two fans, one of which blows air outside the case, while another blows it through the card. The cooler is excellent. Six heatpipes and a vapour chamber dissipate heat from the hot running AD102 GPU, while the heatsink is packed with thermal padding for the memory and VRM. When looping Metro Exodus, we saw a peak temperature of 74C. That's great, though the Asus came in even lower at just 61C. It's rather stunning that for all the talk of runaway power consumption and temperatures, the coolers are hardly stressed!

It comes with the 12VHPWR 16-pin power connector. Nvidia includes a 4x 8-pin adapter, though you can get away with connecting only three of them, which still gives you 450W. It's still in an awkward side mounted location that doesn't lend itself to clean cable management. It comes with three DP 1.4a ports and a single HDMI 2.1 port. Nvidia must be privately ruing the lack of DP 2.1 ports, especially given that users buying very high refresh rate 4K or upcoming 8K screens with DP 2.1 will include large numbers of 4090 buyers.

The 4090 FE includes a highly customised and compact PCB. It still manages to include a 20-phase VRM, 24GB of 21Gbps GDDR6X memory and the 608mm² GPU into its compact area. The small PCB allows Nvidia to dedicate nearly half of the total area of the card solely to the second fan and heatsink.

That's useful information, but what we all want to know is how does this beast perform? In one word, it's incredible. Every other graphics card looks sluggish in comparison. We've begun to incorporate a lot more ray traced titles in our benchmarks going forward, and in those cases, the RTX 4090 is twice as fast as the RTX 3080 Ti. In more traditional rasterised titles, the 4090 is the fastest card ever, and by a big margin. The RTX 4090 represents the largest intergenerational performance uplift of any graphics card. And don't forget the importance of DLSS. If you've got it, use it for even higher performance, though if you're running 1440p, you might not even need to! We didn't even include 1080p testing as that simply doesn't make sense for such a card.

The RTX 4090 Founders Edition destroys the myth that reference cards are basic or entry level. But the 4090 is definitely not for everyone. GPUs at close to AU$3,000 can never be universally praised, though if you've got a system and monitor that's deserving of such a card, you'll be rewarded with stunning levels of performance. We can live with the 450W TDP when performance per watt has taken such a big leap forward.

Apart from the steep price, the RTX 4090 excels in all areas. Will AMD be able to compete with better bang for your buck? Stay tuned for that.

The classy Nvidia RTX 4090 FE elevates 'reference card' expectations to a new level.
Chris Szewczyk

★★★★½

■ Nvidia GeForce RTX 4090 Founders Edition; 16,384 CUDA cores; 2,520MHz boost clock; 24GB GDDR6X 21Gbps memory, 1,008GB/s memory bandwidth; 3x DisplayPort 1.4a, 1x HDMI 2.1; 450W TDP, 1x 16-Pin power connector.

Asus ROG Strix GeForce RTX 4090 OC Edition

If you want the best of the best...

■ $3,799 | www.asus.com

If you thought the RTX 4090 Founders Edition was big, check out the Asus ROG Strix. If you're into bicep curls, the weighty Asus is here to help! Seriously though, the Asus is a big and heavy card. It features a futuristic look with RGB and a lot of the appealing little touches we've come to expect from high end Asus ROG products.

The Asus comes with a factory overclock, with an official rated boost clock of 2,610MHz, an increase of 90MHz over the FE. The memory clock remains unchanged. It also comes with an eye watering price, at $3,799, a good $800 more than the 'basic' 4090s.

Asus has gone all out with the 4090 Strix. It's a quad slot card with an enormous vapour chamber cooler and seven heatpipes. The underneath of the heatsink is dotted with an array of thermal strips to keep the memory chips and VRM cool. There's also a thick backplate. Load temperatures maxed at just over 60 degrees, that's stunning for a 450W card, though at the same time, not entirely unexpected with this kind of cooling capability.

The PCB is simply extreme. This 24-phase design with 70a stages looks like it was built with the expectation of 600W TDPs or more. Should a 4090 Ti eventuate, or you wish to overclock your card, this design will happily accommodate it. Note that the PCB is still quite compact, in terms of length. This allows Asus to follow the recent trend of blowing air through part of the card.

Asus includes a 4x 8-pin adapter for use with the 16-pin 12VHPWR adapter, which can deliver up to 600W. Like other 4090s, make sure the connector is 100 percent inserted with as little bending as possible to avoid any potential issue.

Asus usually includes some extras over and above the FE card. In addition to the monster cooler and higher clocks, you get dual BIOS, with a switch to choose between default and low noise settings. There are a pair of 4-pin fan headers too, which is very useful for adjusting external fan speeds according to the GPU temperature.

The video output complement is excellent. Though it still misses out on DP 2.1, you get dual HDMI 2.1a and three DisplayPort 1.4a. You can use up to four ports at the same time.

The Asus outperformed the Founders Edition, but not by as much as you might expect. The advertised boost clocks generally mean little. In reality, if you have the power headroom and cooling overhead, the card will boost much higher than its rated clock. In our testing in an open testbench, the card was happy to hold clocks in the range of 2,750 to 2,800MHz, and with that you get a shocking amount of performance, though again, not a lot higher than that of entry level 4090s – 'entry-level', being a relative term.

The Asus 4090 Strix is extreme in every way. It's the card to buy if you're after a genuine flagship that looks the part, while offering performance, cooling and low noise levels to match it. Top tier ROG products usually come with premium price tags, though if dropping $3,000 or more on a graphics card is acceptable to you, what's a few hundred bucks between friends? If the FE is a V8 Ferrari, the Asus is the V12 version.

The Asus Strix improves over the FE in every way with typical ROG flourishes, though be prepared to pay a hefty premium.

Chris Szewczyk

★★★★½

■ Asus ROG Strix GeForce RTX 4090 OC Edition.; 16,384 Cuda cores; 2,610MHz boost clock; 24GB GDDR6X 21Gbps memory, 1,008GB/s memory bandwidth; 3x DisplayPort 1.4a, 2x HDMI 2.1; 450W TDP, 1x 16-Pin power connector.

NVIDIA GEFORCE RTX 4090 CONCLUSION

2022 finally delivered.

It's always exciting to see a new GPU generation. Nvidia has really knocked it out of the park, but you'll have to pay a steep price for the privilege of owning one. If you're lucky to own a high resolution and high refresh rate screen, this is your GPU. Turn up all the graphics options and you'll enjoy hundreds of FPS in most games. Even demanding ray traced titles have seen a dramatic leap forward in performance.

The last quarter of 2022 has been the best time in many years to be a PC gamer. There's new GPUs and CPUs to choose from, and gaming performance is better than ever. But price matters, and three grand is a lot to pay for just a GPU, no matter how fast it is.

Then there's the imminent release of AMD's RDNA 3 range, led by the RX 7900 XTX and RX 7900 XT. AMD appears to be positioning these cards as RTX 4080 competitors, but until we test them independently, it's hard to say how they will stack up. It might be worth waiting a few weeks to see the lay of the land, but if you've got money burning a hole in your pocket, you just know that the 4090 won't let you down when it comes to all out pixel pushing prowess.

A note on benchmark testing. Where applicable, we've run our benchmark suite with most of the ray tracing settings enabled. This makes the Radeon RX 6000 cards look quite poor in many instances, however, our updated ray tracing testing will be more relevant to RX 7900 series cards, and all graphics cards going forward.

			Nvidia GeForce RTX 4090	Asus ROG Strix GeForce RTX 4090	Nvidia GeForce RTX 3080 Ti	Nvidia GeForce RTX 3080	AMD Radeon RX 6900 XT	AMD Radeon RX 6800 XT
Hitman 3	2560x1440 Ultra Preset	Avg	145	146.8	79.3	73.5	53.2	50.1
	3840x2160 Ultra Preset	Avg	87.5	87.9	42.3	38.4	27.6	28.8
Cyberpunk 2077	2560x1440 RT Medium Preset	Min	65.6	66.1	41.2	37.8	26.8	25.9
		Avg	92.7	93.4	53.8	49.8	37.1	35.4
	3840x2160 RT Medium Preset	Min	33.0	32.9	19.7	16.9	12.1	11.7
		Avg	46.9	47.3	26.6	23.8	17.1	16.3
Far Cry 6	2560x1440 Ultra Preset	Min	118	126	104	116	107	110
		Avg	154	156	128	130	136	132
	3840x2160 Ultra Preset	Min	121	123	77	70	78	74
		Avg	133	134	85	79	85	82
Tiny Tina's Wonderlands	2560x1440 Badass Preset	Avg	219.9	223.7	125.2	113.9	131.1	122.7
	3840x2160 Badass Preset	Avg	129.6	130.3	71.3	64.2	68.5	64.7
Ghost Recon: Breakpoint	2560x1440 Ultimate Preset	Avg	168	168	112	108	127	111
	3840x2160 Ultimate Preset	Avg	119	120	78	72	75	64
Horizon Zero Dawn	2560x1440 Ultimate Quality	Avg	173	177	147	131	155	148
	3840x2160 Ultimate Quality	Avg	154	154	92	80	85	81
Civilization VI	2560x1440 Max Settings	Min	274	287	184	170	180	171
		Avg	335	344	237	220	224	214
	3840x2160 Max Settings	Min	218	215	139	125	123	117
		Avg	268	268	173	157	149	142
Temperatures ©		Idle	46	44	44	34	44	43
		Load	74	61	74	74	78	73
3DMark		Time Spy Extreme	16,683	16,785	9,006	8,295	8,775	8,502
		Fire Strike Extreme	38,263	39,360	21,248	19,952	23,020	22,915
		Port Royal	25,507	25,731	13057	11,696	9,739	9,303
		RT Feature test	138.10	139.23	53.11	48.73	26.53	24.65

APC TESTBED **CPU:** Intel Core i9 12900K, **Motherboard:** Asus Maximus Z690 Apex, **RAM:** 2x16GB G.Skill Trident Z5 DDR5-6000, **Power Supply:** Corsair AX1000, **Storage:** 2TB Seagate Firecuda 530, **Case:** Thermaltake Core P8, **Cooling:** Cooler Master Flux PL360 AIO, **Operating system:** Windows 11 Pro 22H2

The free frames miracle

BENNETT RING EXPLAINS THE UNBELIEVABLE BUT REAL BENEFITS OF DLSS 3.

Work smarter, not harder, seems to be the motto behind one of the key new technologies in Nvidia's RTX 4090 GPU. Rendering games at 4K is a significantly harder task than the previously dominant gaming resolution of 1080p, requiring a whopping 300 percent more pixels to be displayed on screen, but the 4090 is arguably the first GPU to deliver no-compromise 4K gaming. Yet rather than simply throw more transistors at the problem to brute-force 4K performance into submission, the 4090 includes a clever suite of technologies called DLSS 3 to make high framerate 4K gaming a reality, and it looks like the rest of the 4000 line-up will include these. We spoke to Bryan Catanzaro, from Nvidia's Applied Deep Learning Research team, to find out what it is, and how it works.

DLSS 2 – a recap

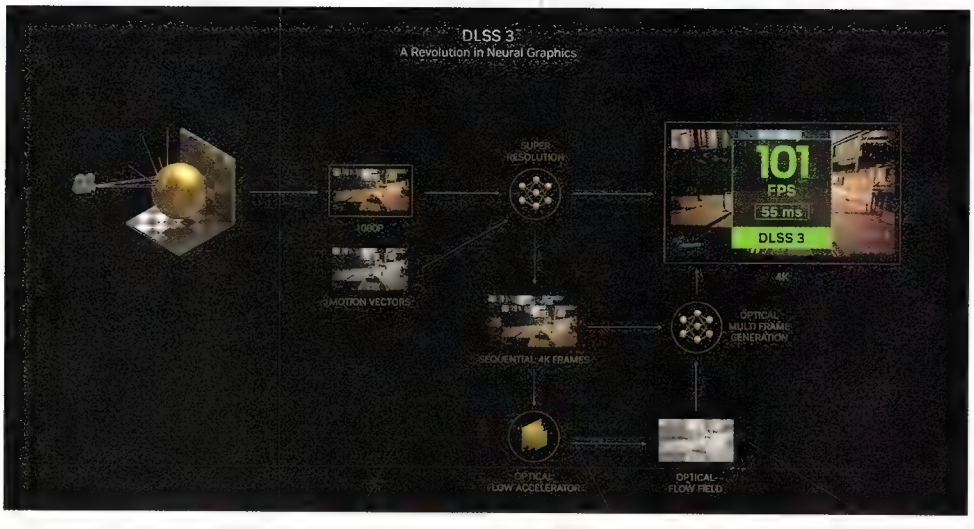
If you're a high-end PC gamer, chances are you're already familiar with Nvidia's DLSS 2 technology. Standing for 'Deep Learning Super Sampling', this temporal anti-aliasing upsampling technology allows the GPU to render the game at a lower resolution, then uses clever AI algorithms and a little hardware acceleration to display the scene at a much higher resolution. For example, if you select a 4K resolution, but enable DLSS 2's highest quality mode, the GPU internally renders each frame at just 2560 x 1440 resolution, and then upscales it to 4K. Lower quality DLSS settings render internally at even lower resolutions, and the result is a performance increase of up to 300 percent over native 4K. It relies upon Nvidia's Tensor cores to run, which have been present since the RTX 2000 series of GPUs. The technique is so good that, on an average 27-inch or 34-inch screen at least, it can be very hard to tell the difference between native 4K and DLSS 2's upscaled version.

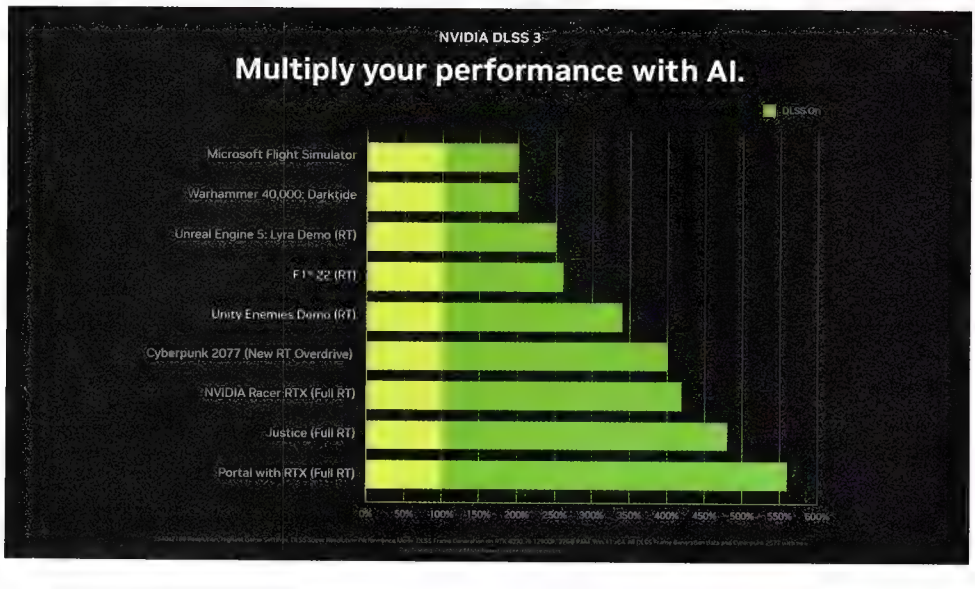
Frame Generation

DLSS 3 includes the temporal upsampling of DLSS 2, but expands on it with a brand new feature called Frame Generation to increase frame rates even more. Put simply, for every two 'real'

© Nvidia

The numbers don't lie. DLSS 3 can make previous chugfests into silky smooth experiences.





LEFT: Nvidia's DLSS 3 inserts completely AI generated frames, which is why it delivers such high percentage gains.
BELOW LEFT: DLSS 3 is mathematical simplicity in terms of the gains you can expect, with a neat and tidy doubling right there for the taking.

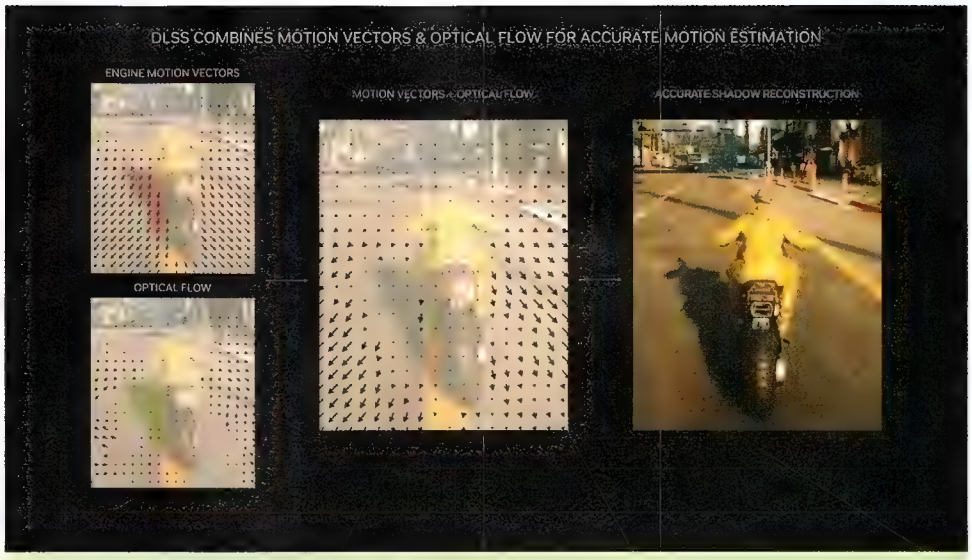
frames being generated by the GPU and CPU, Frame Generation creates a totally artificial frame using extremely minimal resources, and slots it in between the two frames. The diagram from Nvidia shows the flow of frames in a traditional render queue versus one with Frame Generation.

The beauty of this technique is that the new frame doesn't need to be calculated in the same resource-intensive way as a traditional frame. Instead, Frame Generation looks at the differences between the two frames using motion vectors, which is information provided by the game's renderer that suggest how one frame will differ from its precedent. These same motion vectors are used by DLSS 2, as well as more widely used Temporal Anti-Aliasing methods, so enabling support for DLSS 3 should be relatively easy.

The implications for performance are obvious, with increases of 50 percent being possible solely from Frame Generation. Throw in the fact that DLSS 3 also includes the temporal upsampling of DLSS 2, and it's possible to see a staggering 300 percent performance increase with DLSS 3 enabled versus native 4K resolution. In fact, if you look at this slide from Nvidia, you'll see that with both upsampling and frame generation enabled, 87.5 percent of all pixels can be 'artificially' created, using what appears to be minimal hardware resources.

While DLSS 2.0 relied upon Nvidia's Tensor Cores to accelerate the algorithm, Frame Generation uses Optical Flow Accelerators, a part of the GPU which first debuted in the Turing architecture found at the heart of the RTX series. Nvidia has been very secretive about these parts of the GPU, and refused to tell us just how many of the 4090's 76 billion transistors are dedicated to the job. Given the secrecy, we're guessing that it's not many. Unfortunately, if you're the existing owner of an RTX 2000 or 3000 GPU, both cards which also feature Optical Flow Accelerators, don't get too excited though, as DLSS 3's Frame Generation is locked to the RTX 4000's Ada Lovelace architecture. Users have managed to unlock the feature on

ABOVE LEFT: Supported games benefit from ongoing AI evolution, with improvements in image quality and a reduction in artefacts expected over time.
LEFT: Finally ray tracing is possible without crippling your game's performance.


DLSS COMBINES MOTION VECTORS & OPTICAL FLOW FOR ACCURATE MOTION ESTIMATION
ENGINE MOTION VECTORS
OPTICAL FLOW
MOTION VECTORS + OPTICAL FLOW
ACCURATE SHADOW RECONSTRUCTION

RIGHT: DLSS Frame Generation is no easy task, with every element of the frame needing to be predicted one frame in advance.

previous cards, but the results are not good; according to Nvidia, the Optical Flow Accelerators of the previous generations just aren't fast enough to work well.

Faster frames, but higher latency

When DLSS 3 was first announced, many were quick to realise that it could see an increase in system latency. Instead of churning out frames as quickly as possible, Frame Generation needs to look at two frames in sequence, calculate the new frame, and insert it into the middle. Traditionally higher frame rates meant lower latency, but this is not the case with Frame Generation.

To get around this, DLSS 3 leans heavily on Nvidia's Reflex technology, which improves system latency considerably. If Frame Generation is enabled, Reflex is automatically switched on, unlike upsampling, which can be disabled.

Hands on with DLSS 3

At the launch of the 4090 there were just a handful of games to support the feature, and we selected three for testing. In *Spider-Man*, a game that relies on fast responses, we found it very difficult to notice any increase in input latency. This is because the game already runs at extremely high frame rates (and thus extremely low input latency) on the 4090. Ditto with *F1 22*, which is one of the best case scenarios for Frame Generation, as input latency doesn't need to be so rigorously low. However, in both *Cyberpunk 2077* and *A Plague Tale: Requiem*, where the native frame rate could hover as low as 40fps, we did feel a very slight increase in input latency. Yet it wasn't enough to forgo the huge increase in perceived smoothness though, but we think for competitive shooters most users will prefer to disable the feature.

Frame Generation for all?

DLSS 3's new feature is just the latest in a string of technologies which Nvidia has created with the potential to become an industry standard, just like Variable Refresh Rates (G-sync), temporal upsampling (DLSS) and low input latency (Reflex). Given how transformative the technology is, we're sure to see something from AMD and Intel in the future, but it's unlikely to be this generation. In the meantime, Nvidia users can rest assured that the already impressive native performance of the 4000 series is only going to get better as support for DLSS 3 is rolled out.

INSIDE THE DLSS 3 TECH

APC's Bennett Ring asked Nvidia to explain more about DLSS 3, and what the future holds.

Does the resolution upscaling within DLSS 3 differ from DLSS 2 in any way?
No. Super Resolution and Frame Generation are independent options included in DLSS 3. DLSS Super Resolution has improved significantly over the years in both image quality and FPS, and we anticipate continued improvements to DLSS Super Resolution going forward.

Why the confusing naming of DLSS 3, as DLSS stands for Deep Learning Super Sampling, yet DLSS 3's feature has nothing to do with super sampling?
DLSS is a pioneering AI-powered technology that improves on all three aspects of gaming graphics rendering: image quality, frame smoothness, and low latency responsiveness. This is true for DLSS Super Resolution, and it is also true for DLSS Frame Generation. We felt that since the goal was the same, it made sense to refer to these technologies together.

One of the few noticeable visual issues with frame generation occurs when scenes change, or games swap from a static menu screen to in-game. Will frame generation technology be improved to remove this issue? Is it possible to remove the HUD from the area being treated by frame generation, as we've seen with DLSS 2?
The scene change issue is considered a bug and should be fixed. Games already provide a flag to TAA or DLSS in order to deal with scene changes, but this flag was not properly handled in DLSS 3.0. This will be fixed quickly. We also have some changes to how DLSS Frame Generation handles the HUD that we expect will significantly improve HUD generation quality in the short term.

Does Nvidia recommend frame generation for games with lower frame rates (40-60fps), or is it best suited to games which already have high frame rates (100fps+)?
To achieve the best gaming experience with DLSS Frame Generation, the AI network's input frame rate must still perform at a level such that the main game loop, input handling, and simulations run well. If these elements aren't updated fast enough, the game itself can feel sluggish.

The exact input frame rate needed varies based on game genre, the game engine and other factors. DLSS 3 includes DLSS Super Resolution which helps boost the input frame rate (including the main game loop) for DLSS Frame Generation by up to 2x. For example, the game could render natively at 25-30 FPS, be boosted by Super Resolution to 40-60 FPS, which provides a solid input frame rate for the Frame Generation AI network to boost FPS by up to another 2x (to 80-120 FPS).

Note that RTX 40 Series GPUs have the raw performance to render the majority of games well above 25 FPS at native resolution. Particularly as we address some of the UI image quality issues mentioned above that become more apparent at lower FPS, we believe input frame rate concerns will become even less of a factor.

Currently V-sync isn't officially supported with frame generation – will this change in the future?
Several press also provided feedback that they would like V-sync to be supported with DLSS 3. We agree and have improvements for V-sync support in the works.

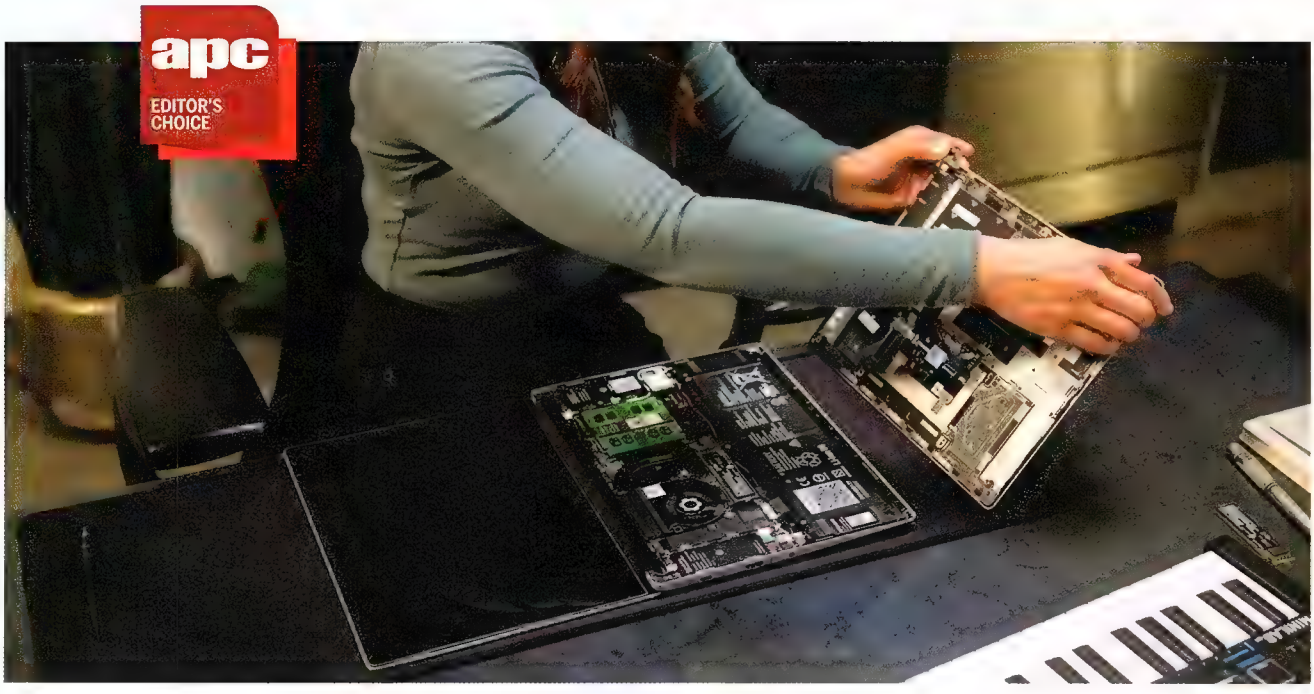
How long does it take in man-hours for a game developer to implement DLSS 3?
DLSS Frame Generation is implemented using Nvidia Streamline, and it requires essentially the same inputs as DLSS Super Resolution, with the additional requirement of implementing Nvidia Reflex to reduce latency. We learned a lot about how to integrate DLSS into games over the past four years and we build upon that experience to making the DLSS Frame Generation as easy to integrate into as many games as possible. ■

DO-IT-YOURSELF LAPTOP

Framework Laptop DIY Edition

A compelling do-it-yourself laptop that looks indistinguishable from a modern Ultrabook.

■ From $1,594 | frame.work/au/en



■ W11 Home; 13.5-inch 400 nit display at 2256 x 1504 pixel resolution; Intel Core i7-1280P CPU; Intel Iris Xe Graphics; 16GB RAM; 55Wh battery (10h12min PCMark 10 Home Battery); 29.7 x 22.9 x 1.6cm; 1.3kg.

If you like to do things the hard way – and, let's face it, anyone interested in buying a laptop that has to be built from the ground up isn't afraid of doing difficult things – then the Framework DIY Edition is the easiest hard-way you can go.

The initial setup is pretty straightforward thanks to a comprehensive set of instructions available on the Framework website. Basically this consists of unpacking the various customisations you bought, popping the hood and plugging each component into its easy-to-access slot under the keyboard.

The online DIY manuals contain concise instructions and a set of annotated images for those moments when words just aren't quite enough to describe exactly what needs to be done. The Framework DIY unit comes with your very own, single size star screwdriver that flips to become a soft pry bar for teasing apart clasped components.

While the screws that you have to undo on the framework laptop look a lot like something you'd see on an Apple product, they function very differently with easy removal and a neat catchment mechanism that means they'll remain attached and in-place once undone, so you won't lose them.

Once inside it's all pretty straightforward with the locations for the Wi-Fi module, RAM sticks and the SSD all clearly labelled with names and a QR code that'll take you to the part of the manual needed to install. There's still the small fiddly details you get on some connections, but with precise instructions on how each component works there's none of the daunting moments where you're not sure if you're installing something correctly that you get with a standard PC build.

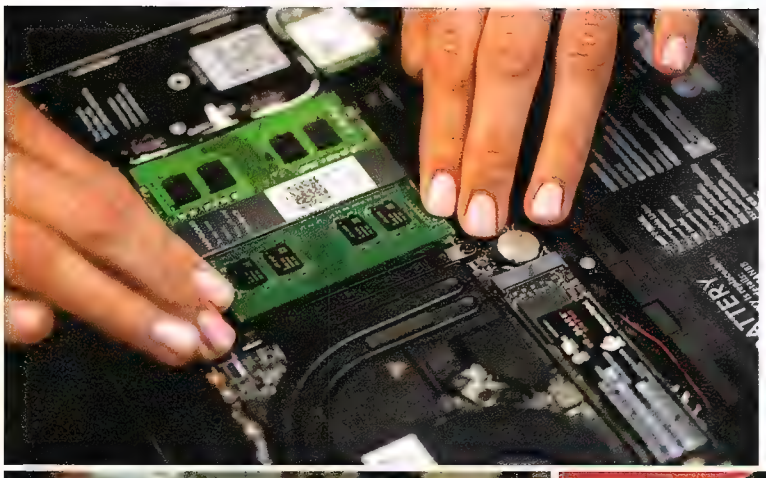
Once you've pieced together your new laptop you'll need to clean install Windows... or your choice of Linux, Fedora and Ubuntu. If you haven't done this before, it's actually a great resource to learn how to load an operating system onto a computer that contains nothing but a BIOS. Basically you'll have to format and load this OS installer onto a bootable USB drive and then navigate to it using the BIOS menu. That USB can then be used to install Windows on any PC you connect it to in the future, so it's a handy device to have around for those moments you run into an unresolvable issue.

At this point you end up at the place most people start at when they open the box of a $2k Ultrabook, but at least you're likely to feel a lot more accomplished than if you just unwrapped some plastic. You'll also have a device that you can easily upgrade as the need arises, whether that's in one or five years.

	Framework DIY (12th Gen i7)	Framework DIY (11th Gen i5)	MSI Prestige 14Evo A12M
PCMark 10 - Overall (score)	5,064	4,685	5,073
Geekbench 5 - Multi-core (score)	7,133	4,583	8,721
Cinebench R23 - CPU (multi-threaded)	10,660	4,618	11,441
3DMark - Time Spy (score)	1,599	1,195	2,118
Battery life - PCMark 10 Battery Home Work (h:min)	10h 12min	6h 18min	8h23min
Peak CPU temperature (°C)	100	93	Not Recorded
CrystalDiskMark Read (MB/s)	3,434	3,435	6,561
CrystalDiskMark Write (MB/s)	2,703	2,719	4,766

Upgrading the CPU and mainboard

It's not unreasonable to wish you had an updated CPU on your laptop after a



couple of years and if you could pair that with a new SSD and faster RAM, you've basically got a new laptop, in terms of performance. This is exactly what Framework's 12th Gen Upgrade Kit is designed to let you do, since you can swap out the components you want without throwing out anything that's still working perfectly well.

It's not cheap... the motherboard and CPU cost around 50 percent of the final Framework laptop price, but if everything else on your laptop is in top shape and can be updated whenever you need to, down the track, then it's an upgrade that makes a lot of economical (and environmental) sense.

The 12th Gen Upgrade Kit gets the same 'Moderate' difficulty label as the initial setup for the Framework DIY, but it is definitely a step up in terms of technical capability. Not that any particular individual task is overly complicated on its own, but once you've got 30 simple assembly instructions stacked on top of each other, you've essentially dismantled the majority of the computer and it can seem a little daunting thinking about piecing it back together.

Fortunately, the instructions are sound and do a good job of navigating you back to a working device. All the individual elements from the magnetic bezels to the cable management have been designed in a way that make it exceptionally easy to dismantle and reassemble, a task that takes a lot more design effort on a compact laptop than a roomy desktop PC. And apart from a couple of moments where we wish there was an additional picture or instruction, for the most part the guides are exceptionally concise and thorough.

Performance

While the Framework DIY laptop is clearly designed as a laptop building experience, you're also buying something that you'll actually have to use for work, study or entertainment, so it's important to consider how it fares as a usable laptop.

> "The only obvious downside is that it is expensive against the best value consumer devices."

The 13.5-inch display offers a solid 2256 by 1504 pixel resolution that looks vibrant and is more than bright enough to still look good in bright office environments. We tested both the 11th Gen i5-1135G7 and the powerful 12th Gen i7-1280P processors and found that both performed as well as you would expect. The former here outperformed a Surface Laptop Go 2 with comparable specs in general work tasks, while the i7-1280P was up to about 10 percent behind an MSI Prestige 14 Evo A12M with the same setup. Even though it wasn't quite up to MSI's offering, the 12th Gen Framework DIY offered between 50 and 230 percent improvements on the 11th Gen i5, so it's well worth the upgrade cost and both are more than capable of handling your average workload.

The keyboard is surprisingly nice to type on and the trackpad is smooth and offers all the modern gesture features you'll find on other devices. It's even got a fingerprint reader, 1080p webcam, Wi-Fi 6E networking and a set of decent speakers. Battery life was solid on the 12th gen device lasting over 10 hours in general work tasks and the 11th gen unit managed close to a full work day.

The only obvious downside is that it is expensive against the best value consumer devices. The Microsoft Surface Laptop Go 2 we mentioned earlier costs $1,299 and the MSI Prestige 14 Evo A12M with a 12th Gen i7 costs $2,199, against the Framework's current starting price of $1,639 for a 12th Gen i5 or $2,942 for the i7 with 16GB of RAM and a 1TB SSD.

A unique Ultrabook that works well and allows for easy repairs and DIY upgrades.

Joel Burgess

★★★★½

LAPTOP

Fujitsu Lifebook U9312

A novel Ultrabook from Fujitsu that's all about business, not pleasure.

■ $3,948 | fujitsu.com/au

Fujitsu isn't exactly a well known player in the laptop space – at least, nothing like its glory days of the 1990s and 2000s – but its extensive range of technologies put it in a good position to make these machines. This is at least part of the story as to why the Lifebook U9312 is such a sophisticated device. The other part of this equation is that everything from the highly-efficient processor to the uncommon eSim compatibility has been carefully curated for a particular type of business consumer that could actually really appreciate this device.

We don't usually cover products that are explicitly designed for enterprise purposes rather than your regular work-from-home consumer, but the Lifebook is available through enough regular retail outlets for it to be available to everyday consumers... as long as they're happy to pay the inflated price tag for the business perks.

The Fujitsu Lifebook U9312 comes in a few configurations with options of an i5 or i7 12th generation Intel Core U series processor, up to 32GB of RAM, various SSD sizes and the option of 4 or 5G capable onboard mobile broadband. The most affordable of these we've seen offered for $3,335, but Fujitsu has left vendors to largely set their own prices so don't expect the lowest specced units to have the lowest advertised price.

At the other end of the spectrum we've seen high specced units asking for $4,348, a price that's usually reserved for gaming laptops and workstations with discrete graphics and high specced screen, of which the Fujitsu Lifebook U9312 has neither. It's a lot of money when you consider the 13.5-inch touchscreen IPS display has a resolution of just 1920 by 1080 pixels and offers a maximum peak brightness of 350 nits. The i7-1265U processor on the device we tested offered comparable performance to $1,500 ultrabooks running an Intel Core i5-1240P, a comparison that illustrates just how high that starting pricetag is.

■ W11 Pro; 13.3-inch 350 nit IPS display at 1920 x 1080 pixel resolution; Intel Core i7-1265U CPU; 32GB RAM; Intel Iris Xe GPU; 512GB Gen 4 PCIe SSD; 65Wh battery (12h55min 1080p movie playback); 30.7x19.7x1.6cm; 917g.

Fortunately there are some features that go at least some of the way to justifying the cost. The first is the weight, it's a lot lighter than most 2022 ultrabooks, with the unit we tested weighing just 917g compared to the 1.2 to 1.5kg you'd expect to see. Part of this is likely down to the lower wattage CPU that can scale down to draw just 15W when not being used heavily and therefore reduces the need for large batteries. Despite being a conservative size the battery gets a 65Wh rating thanks to the lower CPU draw, which keeps it running 13 or 14 hours for 1080p movie playback or light work, respectively.

There's also a number of features that will appeal to business users like the use of Windows 11 Pro and Intel's vPro hardware security, remote management, and improved stability features. It's got other uncommon business focused features like the option for eSim network connectivity and an optional PalmSecure sensor (a piece of proprietary Fujitsu security tech). The kicker is a 3-year warranty that includes a next-business-day service for laptops located within metro areas.

If you're not interested in the business features it's difficult to see the value here, but for anyone looking at options for an enterprise fleet this seems like a well designed option.

	Fujitsu LifeBook U9312	LG Gram 2-in-1 16
PCMark 10 - Overall (score)	5,178	5,125
Geekbench 5 - Multi-core (score)	6,138	7,792
Cinebench R23 - CPU (multi-threaded)	5,288	6,824
3DMark - Time Spy (score)	1,503	1,631
Battery life - 1080p video playback (h:min)	12h55min	13h22min
Peak CPU temperature (°C)	100	100
CrystalDiskMark Read (MB/s)	6,751	6,951
CrystalDiskMark Write (MB/s)	3,833	4,350

A streamlined lightweight business Ultrabook with enterprise perks for a price.

Joel Burgess

★★★★☆

ULTRAPORTABLE LAPTOP

Lenovo Yoga Slim 7 ProX (14", Gen 7) AMD

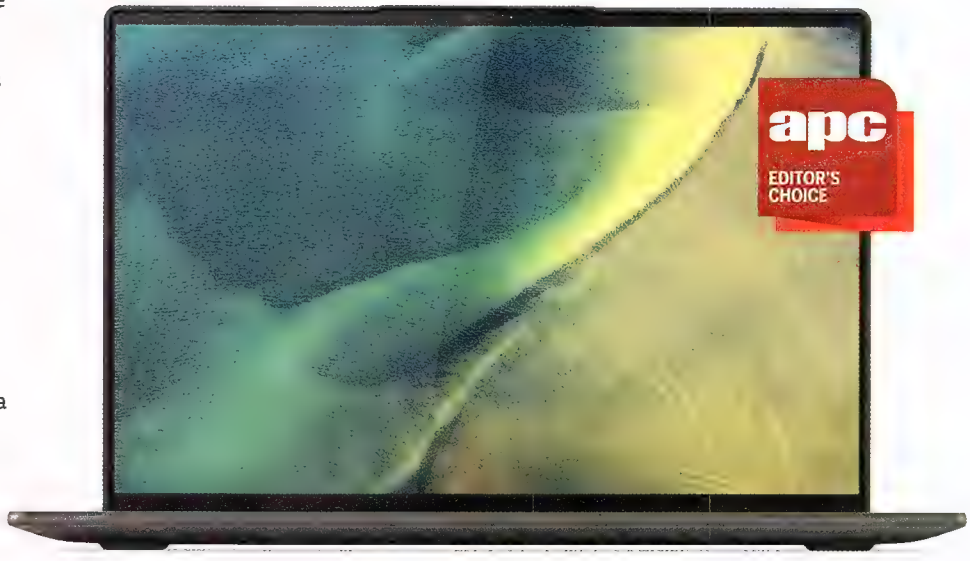
Lenovo's new Yoga looks like it could be a Surface Laptop and MacBook Pro killer.

■ $3,349 | lenovo.com/au/en

We gave full marks to the 2021 Yoga Slim 7 Pro AMD (*APC 500*), so we were excited to test out the new CPU, discrete graphics and higher resolution that comes with this year's update. The Lenovo Slim 7 ProX (14", Gen 7) AMD's major changes do come with the downside of a more weighty price tag, but they also make it more appealing to a different type of Ultrabook user.

While all the new updates initially seem like steps forward, there's actually some tradeoffs that perhaps weren't considered. Take the screen, for example, the new 14.5-inch 3.5K screen offers a higher resolution and a faster 120Hz refresh rate (up from 90Hz) that should compliment the additional power from the Nvidia GeForce RTX 3050 GPU. And if you lean into high-refresh competitive online gaming then the extra 30fps you'll get from the update will be great. This added speed does, however, come at the cost of brightness and colour capabilities, since the screen has been downgraded from a 600nit OLED with full DCI-P3 colour capabilities to a 400nit IPS that just scrapes 100 percent sRGB colour. This is a major step back in terms of how the screen looks in everyday use and when you consider the updated GPU isn't powerful enough to even utilise that faster frame rate in most games... it would have been preferable to keep the original screen.

The Lenovo Slim 7 ProX (14", Gen7) AMD comes with either a hexa-core Ryzen 5 6600HS or an octa-core Ryzen 7 6800HS processor, both of which sit in between Intel's two primary tiers of laptop processors. This processor is capable of 10-20 percent performance bumps in some tasks over the 2021 model according to our benchmarks, a fact that surprised us considering both CPUs offer similar core structure, clock speed and power draw. We really don't have anything bad to say about the Ryzen 7 6800HS we benchmarked, since it'll power through any work task you throw at it and its middle-ground power draw makes it competitive against Intel's re-jigged 12th Gen processors when you have a discrete GPU.



■ W11 Home; 14.5-inch 120Hz IPS display at 3072 x 1920 pixel resolution; AMD Ryzen 7 6800HS CPU; Nvidia GeForce RTX 3050 GPU; 16GB RAM; 72Wh battery (11h 7 min 1080p movie playback); 32.8 x 22.1 x 1.6cm; 1.45kg.

> "No matter if you get the $2,649 Ryzen 5 or the $2,949 Ryzen 7 model, both come with the RTX 3050 GPU. "

No matter if you get the $2,649 Ryzen 5 or the $2,949 Ryzen 7 model, both come with the RTX 3050 GPU. This means you can expect playable 30fps+ framerates on any demanding modern games at Ultra 1080p settings, or utilise the 120Hz refresh rate by lowering the graphical detail or by playing older/ less demanding titles. The GPU should also benefit some creative workloads even though this group is likely to feel a little miffed by the diminished colour capabilities.

The PCmark 10 Battery life benchmark was playing up on this unit, but under general web-based work conditions with brightness at 100 percent (you need full brightness on a 400nit screen) we estimated you'll get about 7 hours and a little over 11 hours for 1080p movie playback.

A new 512GB PCIe Gen 4 SSD doubles the read and write storage speeds of the last generation's SSD and you can up that to a 1TB SSD for an extra $400 if you need a little more space.

	Lenovo Slim 7 Pro X (14" AMD)	Microsoft Surface Laptop Studio
PCMark 10 - Overall (score)	6,377	5,036
Geekbench 5 - Multi-core (score)	8,811	4,697
Cinebench R23 - CPU (multi-threaded)	12,114	4,582
3DMark - Time Spy (score)	4,190	4,432
F1 2021 - 1080p Ultra (fps av.)	54	49
Battery life - 1080p video playback (h:min)	10h07min	06h04min
CrystalDiskMark Read(MB/s)	7,061	3,517
CrystalDiskMark Write (MB/s)	5,020	2,979

A powerful, fairly priced ultrabook for those wanting to push gaming or creative tasks further.

Joel Burgess

★★★★½

ULTRAPORTABLE LAPTOP

Asus ROG Zephyrus Duo 16 (2022) GX650

Is Asus's dual screen tech a must have gaming workstation feature or just double the trouble?

■ From $4,699 | rog.asus.com/au

Any serious gaming laptop manufacturer is going to throw its best new tech at the company's flagship gaming battlestation, but we can't think of another device that ends up as unique as the Zephyrus Duo 16. Obviously, first and foremost, this is a serious gaming rig with GPU configurations available all the way up to a Nvidia GeForce RTX 3080 Ti, but Asus has been honing its dual screen technology for many years now which means the Zephyrus Duo 16 is also uniquely suited to power users wanting multiple screens on a laptop.

The main 16-inch screen can be configured as either a 165Hz QHD+ MiniLED display that is perfectly suited to fast and detailed HDR gaming and professional colour work; or as a FHD+ monitor that hits the same 165Hz. While the former here is a pretty amazing offering with uniquely rich and vibrant colours, the refresh rate on the 1920x 1200 display is a bit disappointing, especially when you consider Asus is selling a screen offering both 4K gaming and 240Hz refresh rate capabilities in other regions.

Supporting the main 16-inch display is a second 14-inch ScreenPad Plus display that folds up from above the keyboard when you open the lid. The second screen opens to an angle between the keyboard and the screen to make it easy to transition between the two displays and the 3840 x 1100 or 1920 x 550 pixel IPS screen is detailed enough to not be distracting when you swap between displays. The effect of this is that you get 40 percent more screen real-estate in a format that is perfectly suited to multi-tasking, with a useful suite of software to enhance its functionality.

	Asus ROG Zephyrus Duo 16	Asus ROG Strix Scar 17 SE
PCMark 10 - Overall (score)	7,114	6,893
Cinebench R23 - CPU (Score)	14,275	16,071
Max CPU Temperature (C)	85	96
1080p movie playback (HH:MM)	02:50	04:04
3DMark Time Spy (score)	10,180	13,064
F1 2021 - 1080p Ultra (fps Av.)	117	131
CrystalDiskMark Read (MB/s)	6,552	7,071
CrystalDiskMark Write (MB/s)	4,399	5,004

■ W11 Home; 16-inch 165Hz MiniLED primary display at 2560 x 1600 pixel resolution, 3ms response rate, 100% DCI-P3, Freesync Premium Pro; Pantone Validated, Nvidia Optimus; 14-inch ScreenPad Plus at 3840 x 1100 pixel resolution; AMD Ryzen 9 6900HX CPU; Nvidia GeForce RTX 3080 Ti (165W) GPU; 32GB RAM; 1TB Gen 4 PCIe SSD; 88Wh battery (2h50min 1080p movie playback); 35.5 x 26.6 x 2.1cm; 2.55kg.

Asus sent us the top spec Ryzen 9 6900HX / Nvidia GeForce RTX 3080 Ti model to benchmark. While this unit has an RRP of $5,999, we've seen it available for $5,349. Unsurprisingly, this device ended up being one of the most powerful units we've tested in 2022, but it did come in behind both Intel's top 12th gen i9 CPUs for gaming laptops by up to 10 percent in general work benchmarks. Most users will never feel this distinction since the computer will be able to skip through workloads that would challenge the most premium Ultrabooks, but it's a factor worth considering for anyone puerly interested in performance.

The ROG Zephyrus Duo 16 wasn't the best performer we've seen graphically either with the RTX 3080 Ti being offered with a maximum 165W max power draw. This meant it got fps averages of 117 and 133 on *F1 2021* and *Sid Meier's: Civilization VI* respectively, but this was up to 26 percent behind what we clocked on a ROG Strix Scar 17 with a 175W 3080 Ti (*APC 512*). That said, there's still more than enough power here to game competitively against the top performing gaming laptops and you get a whole heap of additional perks to balance that slight performance compromise.

There are some other caveats that are unavoidable with this adventurous design, specifically, that the keyboard is compressed to the front left of the laptop base to make room for that additional screen. This feeds into a right-handed trackpad that doubles as a digital number pad, which is great for most users, but won't suit anyone hoping to use the trackpad with their left hand. Additionally the powerful components mean the generous 88Wh battery is drained in under three hours for both general work tasks and media playback.

An extremely powerful gaming workstation with unique multi-tasking capabilities.

Joel Burgess

★★★★☆

DUAL ETHERNET WAN ROUTERS

Draytek Vigor2927ax

A high performance business router with Wi-Fi 6, as well as comprehensive redundancy and network management options.

■ $650 | www.draytek.com.au

apc EDITOR'S CHOICE

■ 2x WAN Ports; 5x RJ-45 1GbE LAN Ports; 2x USB 2.0; 802.11ax Wi-Fi; VPN Tunnels: 50; Warranty: 2 years; Size: 241mm x 165mm x 44mm.

Aimed at small to medium business, the Draytek Vigor2927 series router can provide high performance now, yet plenty of room for future network growth. The 2927 is a dual Ethernet WAN router, which means you can combine two internet sources for redundancy or higher throughput. The router comes in a range of models that are identical, aside from having no Wi-Fi, AC1300 spec Wi-Fi with or without VOIP, and the high performance AX3000 spec model we have for testing.

The 2927ax is built around the dual Gigabit WAN ports, which can be configured for failover, load balancing, high available mode and so on. If only using a single WAN port, the other one can be configured as a Gigabit LAN port, to complement the other five the router has. The two USB 2.0 ports can handle 4G modems, access storage, controlling a printer or monitoring temperature via a probe. The inbuilt Wi-Fi is AX3000 spec, which means 2x2 MU-MIMO connectivity at speeds up to 2402 Mbps on the 5GHz band, and a slower but handy 574 Mbps on 2.4GHz.

The 2927 series is security focused, so comes with a feature packed firewall, as well as other network management tools such as app level QoS and even the option to create a hotspot web portal. The router also supports up to 50 VPN connections - 25 of which can be an SSL-VPN. The 2927 can directly control up to 20 Draytek Vigor wireless access points, or eight vigor routers, and 10 switches. The router also supports Draytek's VigorACS software management solutions, which can support remote access via SD-WAN or manage a very large network. Dual WAN makes it much easier to start to max out the possible network throughput, so the 2927 series has inbuilt hardware acceleration. Depending on how that is configured, overall NAT performance can be doubled, and encrypted traffic can be given over three times as much throughput.

The 2927 series has a lot of in depth features we don't have the space to cover here, so it's important to check out the Draytek product page. There is also a fantastic virtual demo of the router, where you can log in and directly test out the interface. You can try before you buy at www.draytek.com/products/live-demo/.

We tested the router's Wi-Fi with a Wi-Fi 6 2x2 equipped laptop, and could hit 588 Mbps up close, and 403 Mbps at a ten meter range. Keep in mind that exact speed depends on what Wi-Fi spec the end device uses, and AX3000 is more about multiple high speed connections at the same time, rather than one stream using all the bandwidth.

We also extensively tested the full featureset, including important aspects such as app level quality of service, VPN creation and dual WAN configurations. The 2927 handled it all with aplomb, and is a solid, reliable choice for business networking. While the 2927ax is well priced for the features, the plan 2927 without Wi-Fi is also great value at $200 less.

The latest Vigor2927ax is a well priced router that offers excellent Wi-Fi 6 performance, as well as top notch redundancy, security and management options.

Lindsay Handmer

★★★★½

ROUTER

Synology WRX560

Welcome to your next Wi-Fi router...

■ $345 | www.synology.com

■ Speed: AX 6,600Mbps | Connectivity: 3 x Gigabit Ethernet WAN/LAN, 1 x Gigabit 2.5Gbps WAN/LAN, 1 x USB-A 3.1 Gen 1 | Features: SRM OS 1.3.1, multi-SSID & network segmentation; enhanced QoS, Firewall, VPN, VLAN, mesh and Family controls.

We were recently blown away by Synology's big push into the Australian router market. Its RT6600ax might have looked dull and ugly, but its performance, features and price changed everything. Now Synology is back with the Subaru-sounding WRX560 which offers similar headline specs and features, but in an even-cheaper, more-family-friendly package.

Our primary gripe with the RT6600ax was that, for all it's slick apps and interfaces, it was still a bit techie for the average Joe. The WRX560 quickly addresses this. Set-up is the simplest we've yet seen: the phone app instantly found our device, asked what we wanted to call our Wi-Fi network and asked for a password. Done. It also addresses our secondary gripe with the RT6600ax – the WRX650 looks much better!

The phone app is well-featured, intuitive and fast. The first two of four tabs seamlessly interlink to show you what's on your network, the bandwidth used plus, you can organise basic QoS priorities and pause each device. You can also easily set-up a guest network and give a QR code to visitors to connect to it.

The Safe Access tab addresses our previous issues about managing employees with parental controls. It enables you to very-easily set-up extensive access and firewall controls for kids, adults and devices. This involves creating profiles which assign internet access scheduling, time-limits and content filtering for individual (or groups of) devices plus content filtering (including real-time access to online Threat Intelligence databases) for kids, employees and guests. There are default categories but they're all configurable. It's one of the most well-featured and easy-to-use filters we've seen and, unlike rival models, it doesn't require a subscription.

> "The performance and features on offer suggest a high price but it costs just $345. This is, frankly, ridiculous."

The Settings tab provides access to the usual prosumer router settings but accessing them via the web-browser provides the best experience on the market thanks to the Synology-NAS-like GUI. All Synology's home and SMB add-on packages are available including advanced VPN, server tools and download managers. The only annoyance is you need to add USB storage to install and use them.

Other features include support for 10 SSIDs to segment devices and people on your network and provided different Firewall controls to isolate or combine them. This is great for smart homes, SMBs and home offices where hackable IoT devices can be locked down and not used to access your important and sensitive data. One of the four network ports offers 2.5Gbps for LAN or WAN connections and other ports can be combined for load balancing. It's a fully featured business router if you need it to be.

Its quad-band Wi-Fi smashed-through our performance tests managing 791.5Mbps up close, 375Mbps two rooms away and an amazing 216.7Mbps down the garden. The latter rivals top triple-node mesh systems!

The performance and features on offer suggest a high price but it costs just $345. This is, frankly, ridiculous. What's more, you can connect multiple models together to create an ultimate mesh network and still save a fortune. As such, the combination of price, features, value, ease-of-use all mean it's on a shortlist of one for most router buyers.

If you had to design your perfect router, this would be it.
Nick Ross

★★★★★

ROUTER

Asus ROG Rapture GT-AX11000 Pro

Is Asus' massive new gaming router too much, too late?

■ $999 | https://rog.asus.com/au/

■ Speed: AX 11,000Mbps | Connectivity: 4 x Gigabit LAN, 1 x 2.5GbE WAN, 1 x 10GbE WAN/LAN, 1 x USB-A 3.1 Gen 1, 1 x USB-A 2.0 | Features: TrendMicro AiProtection, Family controls, Alexa and Google assistant, Game Radar, Game Boost, WTFast ping acceleration, VPN, Media server.

While Synology is owning the show for well-featured, high-performing, great-value Wi-Fi routers, Asus is also making waves. Its latest 'gaming router' eschews sober looks and a friendly price tag for bonkers-level speed and power. We're also pretty sure we once saw one attack the Starship Enterprise. Can it justify the price?

The first thing to note is that this router is really, really big. With its antennae extended, it takes up about a third of a standard office desk, so think about where you might want to house it (it also totally failed the wife test). The ROG decals on the top look impressive and the adjustable RGB befits a 'gaming router' although we're still not wholly convinced that a 'gaming' router is a thing. Still, if it's a pseudonym for arresting looks, top-tier componentry, RGB and a massive price tag, we're in.

Inside there's a quad-core, 2GHz, 64-bit processor, 256MB Flash RAM, 1GB DDR4 RAM and the chassis weighs 2.18KG. So far, it sounds like a laptop. It also has eight, large, quad-channel antennae that operate across a 2.4GHz and two 5GHz bands, to offer a theoretical throughput of 11,000 Mbps. It has four Gigabit LAN ports, a 2.5GbE WAN port and the first 10GbE WAN/LAN port we've seen on a consumer router. There are also two USB-A ports: 3.2 Gen 1 and a USB 2.

After a simple, app-based set-up, we wasted little time running our Wi-Fi performance tests. These see us download large files to a laptop in our Sydney, weatherboard residence from the centre room. Up close, the Rapture scored a massive 825Mbps which is top-tier, but not quite first place. In the front room (two-rooms away) it scored a very impressive 508Mbps which is the fastest single router score we've seen – but also behind the best mesh systems. In the tricky garden test is scored a very impressive 244Mbps which rivals the top mesh systems.

Ultimately, that's incredibly fast but we do feel that with such mighty innards, not supporting Wi-Fi 6E's doubled bandwidth represents an unfortunate bottleneck for a Wi-Fi router that promises ultimate performance. It's certainly impressive but Synology's WRX650 is only a whisker behind while TP-Link's Deco XE75E three-node mesh beats it at distance.

Still, if you're a gamer who's on a mission to banish latency, regardless of cost, the internals will help achieve that. They're backed up by the well-featured Asus router phone app (with Game Mode for best QoS phone performance) and a very-well-featured desktop app with every advanced feature you could want from a consumer router – including subscription-less, Trend Micro-based network protection. It also tracks global game server performance to identify reliability issues, monitors local ping deviation, uses WTFast latency reduction and constantly prioritises gaming traffic.

Ultimately, it's a niche market that wants to pay $1,000 for these gaming features, fast ports and performance ahead of such attractive competition: buying multiple Synologys would provide faster Wi-Fi and save you money.

Too expensive to justify, for most people, while the target market will see its upgraded sibling already on the horizon.

Nick Ross

★★★☆☆

SMARTPHONE

Google Pixel 7 Pro

Is Google's best the new premium king?

■ $1,299 (128GB) | store.google.com

■ 8-core Google Tensor G2 processor; 8GB/12GB RAM; Mali-G710 graphics; 6.7in 120Hz LTPO AMOLED screen, 1,440 x 3,120 resolution; 5G; 128GB/256GB/512GB storage; IP68 rating; triple 50MP/48MP/12MP rear cameras; 11MP front camera; Wi-Fi 6E; Bluetooth 5.2; NFC; 5,000mAh battery; USB-C connector; Android 13; 77 x 8.9 x 163mm (WDH); 212g; 1yr warranty.

Google's Pixel phones have generally been solid mid-range handsets – but with this year's offering, the company's setting its sights higher. The Pixel 7 Pro aims to deliver the best smartphone experience in its generation, while keeping the mid-range price.

It's certainly achieved the latter goal. Launching at $1,299 (with 128GB of storage and 12GB of RAM), the Pixel 7 Pro costs no more than last year's Pixel 6 Pro, and considerably less than an Apple iPhone 14 or a Samsung Galaxy S22 Ultra. Can it really compete with them?

There are three colour options for the Pixel 7 Pro, namely Snow (white), Obsidian (black), and a tasteful grey-green that Google's calling Hazel. We don't love the design: the glossy finish is very fingerprint-prone, and the camera band across the back is likely to divide opinion. You won't be surprised to learn there's no headphone socket either.

The screen however is superb. It's a big 6.7in LTPO OLED display, covered in scratch-resistant Corning Gorilla Glass Victus. we found it exceedingly bright and colourful: technically the iPhone 14 Pro can reach a higher brightness, but there's zero complaints about this one. It's a delight to read, play games and watch videos on, even in bright sunlight.

> "The panel is sharp too, with a 3,120 x 1,440 resolution that translates to a ridiculous 512ppi density – higher even than the Galaxy S22 Ultra's 500ppi"

The panel is sharp too, with a 3,120 x 1,440 resolution that translates to a ridiculous 512ppi density – higher even than the Galaxy S22 Ultra's 500ppi. Looking back through old photos, we could see detail and pick out flaws never previously noticed. A 120Hz refresh rate ensures that moving through the interface and home screens is fantastically fluid.

The screen conceals an in-display fingerprint reader, and while we've had some bad experiences with this type of sensor the Pixel 7 Pro's detection was fast and reliable – we never once had to stab multiple times or try a different finger. You can enable face unlock as an alternative for zero-touch access.

Taking pictures

Photography has long been a strength of Pixel phones, but the Pixel 7 Pro takes things to another level. Somehow, every single photo taken with this phone came out looking exactly the way I wanted. The camera never seemed to focus on the wrong part of the scene, or underexpose the subject against a brighter background. Images looked warm and dynamic, compared to the flat, colder images the iPhone camera sometimes produces.

This is down to some very clever software. For example, Google's Real Tone feature analyses skin tones to make sure images are exposed accurately, while the Top Shot toggle looks for familiar faces in group shots

and makes sure that they stay in focus.

Not all of the Pixel 7 Pro's photographic aspirations fully come off. The Macro mode in particular is disappointing: pictures look sharp, but they don't have the fine detail you get from the iPhone 14 Pro. The 30x Super Res Zoom mode is optimistic too, considering the lens only goes up to 5x optical zoom. The AI doesn't do a bad job of digitally interpolating detail, but the 10x lens on the Samsung Galaxy S22 Ultra produces visibly better results at long range.

Latest Android

Alongside photographic capabilities, another attraction of choosing an own-brand Google phone is that it runs a clean, current edition of Android. In this case that's Android 13, which is easy to use and includes some clever navigation tools. If you want to open an app, change a setting, or jump directly into a feature, you can swipe open a search window, or ask "Hey Google" for help.

Some features are helped along by the Tensor G2 chipset inside the Pixel 7 Pro – a custom, Google-designed processor which is optimised for certain AI tasks. For example, it helps the Pixel 7 Pro recognise speech more accurately than other phones, and translate foreign languages faster.

Google Photos on the Pixel 7 Pro also benefits from a Tensor-aided unblur feature. This works remarkably well, even with photos that weren't taken on a Pixel: some shots from my old iPhone 3GS were dramatically improved.

In benchmarks, Google's Tensor G2 chipset tends to score similarly to other Android phones at around this price point – that is, a little behind the Galaxy S22 Ultra, and far behind the iPhone 14. In use, however, this phone feels at least as fast as the competition, perhaps because Google has been able to tune the OS and the hardware together. Whatever the reason, I found performance to be a non-issue.

> "Photography has long been a strength of Pixel phones, but the Pixel 7 Pro takes things to another level."

Since the Pixel 7 Pro has a full 12GB of RAM, we were even able to run multiple apps at once, and switch instantly between them, although you don't get the multitasking add-ons you'll find on a Samsung phone. Network connectivity is as good as you could ask for: there's 5G for mobile networks, and Wi-Fi 6E for the fastest wireless connections.

You'll get a full day of normal use out of the Pixel 7 Pro, but it won't stretch to two. Adaptive brightness dials the screen down when the ambient lighting permits, but it can also turn it up to very bright levels, and

The Pixel 7 Pro also supports wireless charging in both directions. That means you can charge the phone on a Qi-enabled charging pad, or you can place another device (such as a Pixel Watch), on the back of the Pixel 7 Pro to charge it from the phone's battery.

Time go to Pro

From a purely technical perspective, the Pixel 7 Pro can't match up to the best of today's phones. The Samsung Galaxy S22 Ultra has a bigger camera array, plus stylus support, while the Apple iPhone 14 easily takes the crown for raw performance.

Even so, we enjoyed using the Pixel 7 Pro every bit as much as those flagship handsets. The screen is fantastic and fluid, Android 13 works like a dream – and this phone doesn't just capture phenomenal pictures, it can even enhance ones taken long ago. Through an effective marriage of custom hardware and ingenious software, Google has succeeded in creating an outstanding smartphone at a much lower price than high-end rivals.

A superb all-round phone that is only likely to improve with software updates, and the price is absolutely right.

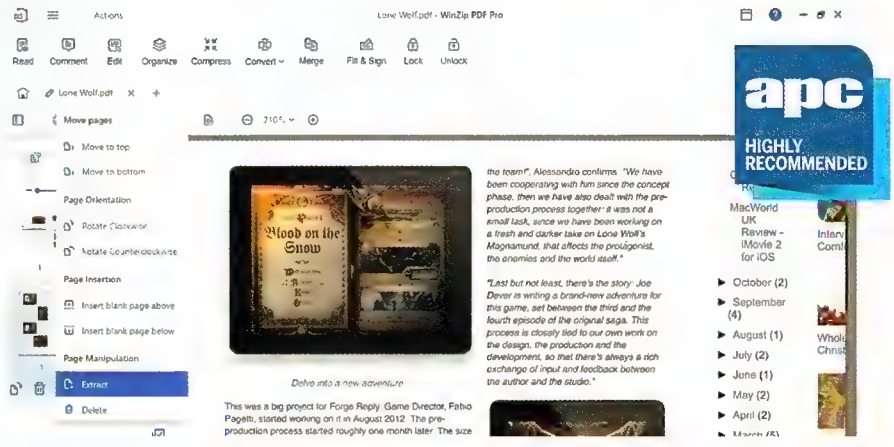
Ben Mansill & Philip Berne

★★★★★

$120.99 per year | winzip.com

WINZIP PDF PRO

A simple interface combined with plentiful features make this a fine alternative to Adobe Acrobat Pro.



The Read tab offers tools to rotate, delete, insert, reorder and extract pages.

WinZip has been a popular tool for compressing and decompressing files since long before Windows came with Zip support. Now from the same stable comes a fully featured PDF editor.

It doesn't make the finest first impression as the app opens with a conspicuous "Make WinZip PDF Pro your default app" banner along the upper part of the screen. I dismissed this, as I find it more convenient to open PDFs in my browser, but it kept popping up each time I opened the application, and I couldn't find a way to disable it.

By default, PDFs open with the Read tab active. As the name suggests, this isn't designed for major manipulations, but it includes tools to rotate individual pages, delete existing ones, insert new pages, reorder the document or extract selected pages as a new PDF. You can also highlight sections of text and mark them for redaction.

Next to it, the Comment tab lets you add notes to PDFs, which I found useful for online collaboration with colleagues. A list of comments is shown to the side of the PDF, and you can click to jump instantly to the relevant part of the document.

For more advanced annotations you can also attach sticky notes in various colours, or add rectangles, ellipses, lines and arrows of various colours and thickness. Freehand drawing tools are on hand too, while the Insert controls let you rubber-stamp a document from a selection of templates, insert new images or drop in attachments.

The Edit tab is of most interest, as this is where you can manipulate the content of your PDF. When you start editing, you'll see a warning that your changes might not precisely match the formatting of the original content – that's a risk with any PDF editor, and I appreciate the honesty as I've seen plenty of other packages screw up the layout without any warning.

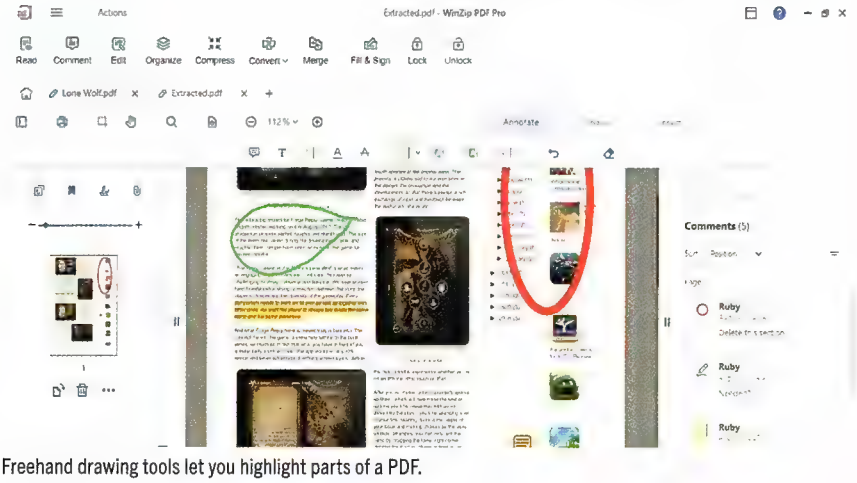
The text-editing process is different to other PDF tools. Rather than typing directly onto the page, you double-click on a paragraph to bring up its content in a popup window; any edits are made here, and when you're finished you can click Apply to update the document. It's a little convoluted, but it sidesteps problems that can arise from the way PDFs treat each line of text as an individual object. The downside is that you can't see your changes on the page until you're done.

You can also resize and move the boxes that contain text and images, although I found this a pain, as the document kept scrolling as I dragged a box, making it hard to place it accurately. Alternatively, you can delete existing boxes and add your own. Once you get the hang of it, it's not hard to get the desired results.

Indeed, overall I found WinZip PDF Pro helped me achieve even quite complex editing tasks. Actions such as adding page numbering, password-protecting a document, applying digital certificates and filling forms were all easy to figure out and execute. That makes it a good alternative to Adobe Acrobat, which might overwhelm non-expert users.

However, there's one unfortunate similarity between the two packages: just like Adobe's offering, WinZip PDF Pro is only available as a subscription, costing $121 per year. That's much cheaper than Acrobat, which costs $225 per year for the Standard edition or $348 for the Pro suite, but there's no good reason why a standalone application such as this shouldn't be available as a one-off purchase: Foxit PDF Editor Pro offers a perpetual licence for $300.

If the subscription-only model is acceptable to you, however, then WinZip PDF Pro makes PDF editing about as effortless as it can be. The process is never going to be perfectly smooth, because PDFs by their nature aren't designed for seamless editing, and I did run into a few irritations while using the software.

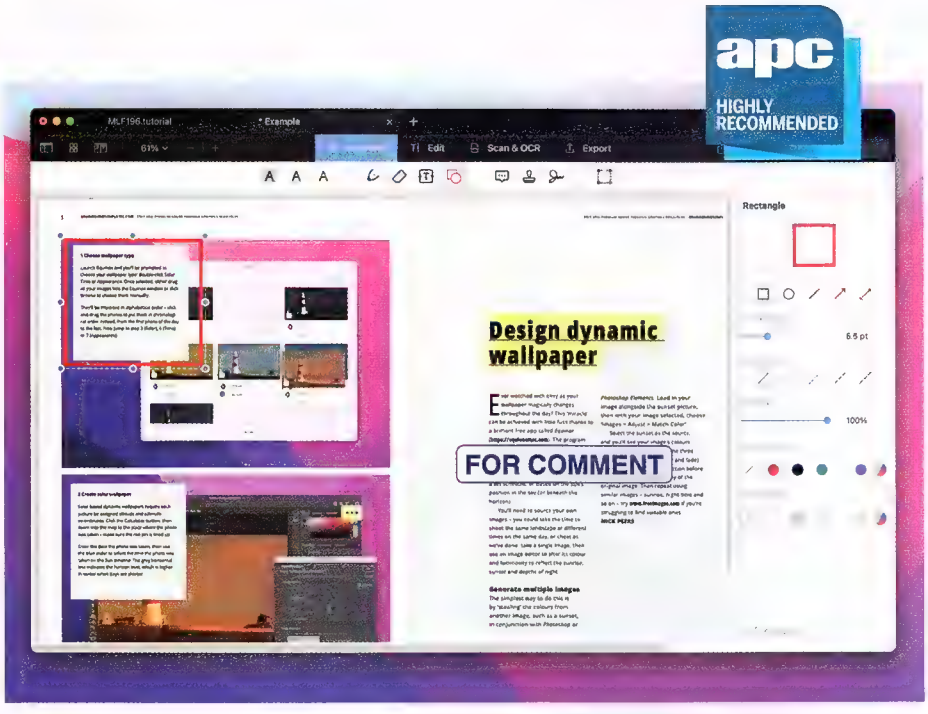


Freehand drawing tools let you highlight parts of a PDF.

Cheaper and more user-friendly than Acrobat, and it will allow you to edit and update PDF files in any way you want.

Steve Paris

★★★★☆



macOS 10.13 or later; iOS 14 or later | $121.99 per year/$219.99 Lifetime (Mac only) | pdfexpert.com

PDF EXPERT 3

Annotate, edit, and extract text from PDFs with this powerful tool.

Above: PDF Expert provides a wide range of tools for marking up and reviewing PDFs.

PDF Expert aims to serve as both a viewer and an editor, dividing its toolset into four basic categories: Annotate, Edit, Scan & OCR, and Export. The annotation tools are par for the course and include highlighting, underlining, or striking through existing text, or marking the document with everything from freehand pen scribbles and pop-up comment boxes to stamps and text boxes.

PDF Expert's best tools by far are its editing ones. If the PDF was created in a tool that outputs its text and images as editable layers, then PDF Expert enables you to easily manipulate existing content as well as add new text and images if required. Images can be moved, resized or swapped out, while text blocks – selected as individual paragraphs – can be moved and edited, plus you're able to change the font, its style, weighting, size and colour. It's all straightforward to use.

If that weren't enough, PDF Expert makes it possible to create clickable links in documents; click and drag where you want the link to go, then choose whether to link to an external website or select another part of the PDF document to jump to. There's also a tool for redacting – you can choose to erase or black out selected content or use a Find and Redact tool to redact keywords or phrases.

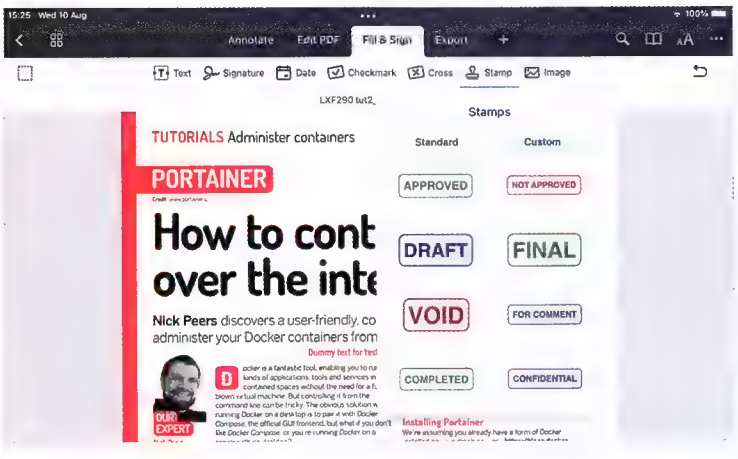
Helper guides help with placing page elements, but one tool that's lacking is the ability to rearrange layers to enable objects to be placed behind and in front of each other.

Aside from a redesigned interface, PDF Expert 3 introduces a new Scan & OCR tool, which can clean up scanned images, help detect page boundaries, and finally – via its Recognize Text tool – attempt to extract a layer of searchable text, which can be edited to remove errors. We say 'searchable' because this tool doesn't convert the document into an editable one, something you'll find in more expensive rivals such as Adobe Acrobat.

PDF Expert 3 also adds a new Export tab, which enables you to export pages as images, plain text or in Microsoft Word, Excel or PowerPoint formats. The success of these depends on the source material – if you can edit the document in PDF Expert, then the resulting document can also be edited in Microsoft Office.

If you opt for the subscription route rather than a lifetime licence, then you can also install PDF Expert on your iPhone and iPad too. The interface is virtually identical and works in a similar way. One key omission is the lack of Scan & OCR controls; instead a Fill & Sign tab provides additional tools for marking the PDF. There are various ways of keeping files in sync between desktop and portable devices, making it easy to switch from one to the other as required.

PDF Expert 3 provides a welcome redesign and slew of new, genuinely useful features. It still lacks a few advanced options, but provides an excellent tool for editing and marking up PDFs.



Pay for an annual subscription, and you can access PDF Expert on your iPhone too.

A user-friendly tool that covers most PDF editing needs.
Nick Peers

★★★★☆

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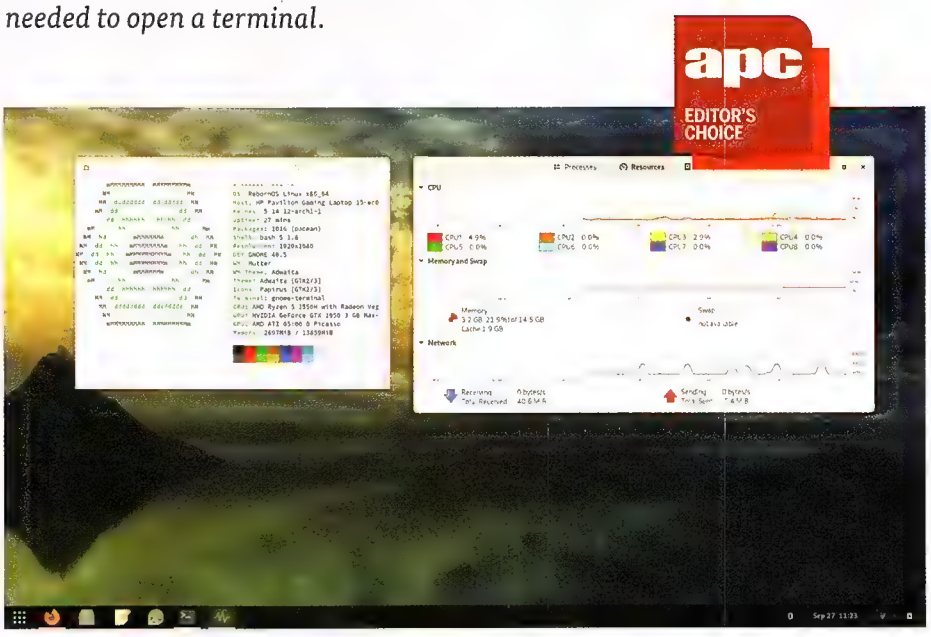
REBORNOS 10.2021

David Rutland's mum ends every conversation with, "I use Arch BTW." With RebornOS, she never even needed to open a terminal.



Neofetch runs every single time you open the terminal. Teach your grandad Ctrl-Alt-T, so he can show his pals that he's a 1337 haxor!

People who keep track of such things will remember Antergos as a nifty Arch derivative that achieved a moderate degree of popularity between its inception in 2012, and its eventual abandonment in 2019 as a result of developer time commitments.

But Antergos didn't die completely. It was resurrected and reworked as the superb EndeavourOS, with a shiny Calamares installer. Furthermore, the mortal remains of Antergos gave life to another distro: the appropriately named RebornOS. This had the stated aim of making, "Arch Linux as user-friendly as possible by providing interface solutions to things you normally have to do in a terminal."

On boot, you'll be given the option of jumping straight to the live desktop, or booting using the latest non-free Nvidia drivers. This is a nice touch – there must be dozens of Linux users with the latest Nvidia hardware who would appreciate using their graphics cards to the max without having to rely on jinky solutions post-install.

From that point, we were on the live USB desktop in under a minute. Installation is via the Antergos Cnchi-derived graphical installer, and was surprisingly trouble-free. RebornOS offers 14 different desktop environments, as well as i3 and Openbox window managers. We chose Gnome, because we're used to it.

While the install progresses, you can visit the RebornOS wiki to gain an overview of the project, view a short list of diverse how-to guides, check out some cool RebornOS-specific software, and peruse the exhaustive installation guide.

Once installation has been completed, you'll find yourself back on the desktop. Oh no! We actually hate Gnome, but we're not technical enough to install another desktop environment! This is where RebornOS Fire comes in handy. It's a graphical package manager that handily groups packages by type and enables easy (and we do mean easy) installation of DEs such as Budgie, Cinnamon, Xfce and LXQt. If you suddenly change your mind and decide that i3 is for you, it's a one-click install for that, too.

> "Oh no! We actually hate Gnome, but we're not technical enough to install another desktop environment! This is where RebornOS Fire comes in handy."

The Fire program also enables easy access to system tweaks and kernel management, although we wouldn't advise taking more than a look unless you know what you're doing. Other documented RebornOS-specific packages include Rate-Mirrors, a tool to help you achieve the best download speeds; and Dart, which is an as-yet incomplete project that promises to assist with troubleshooting problems.

If you'd prefer a more basic package manager, but don't want to wear out your fingers in a terminal, Bauh is pre-installed and offers categorised packages with options to choose (or exclude) AppImage, Arch or Flatpak repositories. It looks good and works well – and the theming is top notch, too.

In keeping with the distro's mission to provide interface solutions to mundane terminal tasks, you'll also find dedicated GUIs for disk usage, hardware info, repository management and system monitoring. These are great for your grandma, but in a timed test, we found it slightly quicker to type `du`, `-sh` and `htop` into a terminal, than to use the mouse to open the menu and either find the icon or type the appropriate name.

RebornOS isn't fully independent yet, and still leans on some of the old Antergos repositories as well as its own. In the distro's current state, it's a worthy rival to its EndeavourOS sibling in the competition to bring Arch to the masses.

There are few Arch-based distros we'd recommend for users with no prior Linux experience. This is one of them.
David Rutland

★★★★½

FEATURE

The electronic component that changed Australia (and the world)

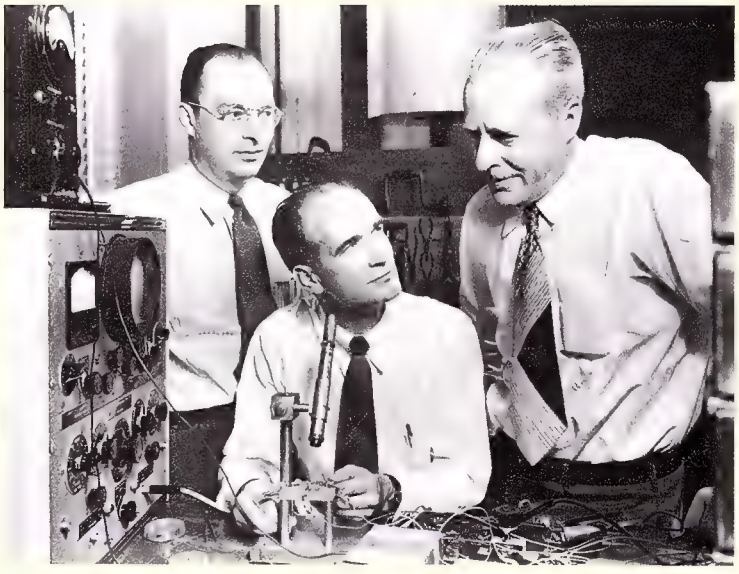
It was a major breakthrough in December 1947 and 75 years later, it continues to change our world. In the final part of this series, Darren Yates looks back at the invention of the transistor.

The new Apple A16 Bionic chip inside the iPhone 14 has almost 16-billion transistors.

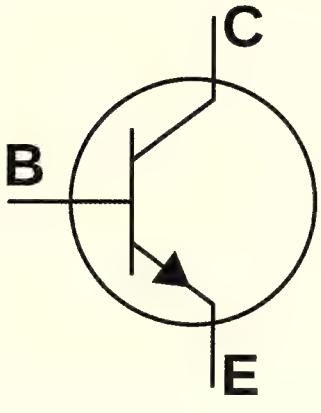
At first glance, it might've look more like a high-school science experiment than a revolutionary step into the future, but 75 years ago this December, a group of U.S. scientists created an electronic component that forever altered the course of human history, heralding in the 'semiconductor age' and giving us technologies past generations could only dream of. But the 'transistor' is also a story of improvement, research and development that continues right up to the present day. This month, we look back at the history of the electronic component that literally changed Australia and the world.

Watt a waste

For 40 years from 1907, the thermionic or electronic valve had not only brought the world into the 'electronic age', it achieved some incredible firsts. As we've seen throughout this series, the valve gave us global communications (Great Britain-to-Australia radio transmissions as early as 1918), it gave us radar in 1935 and Colossus, the world's first all-electronic computer, in 1943. Yet by their inherent nature, valves require a significant amount of power as heat just to function, as much as seven-watts per device (though typically nearer to 4W). While this 'setup power' was modest for a typical five-valve home radio, it soon added up when your computer had 2,200 valves – even at a conservative three-watts per valve, it still would've taken 6,600-watts (6.6-kilowatts) just to turn it on. It's even been suggested that some electrical engineers were embarrassed that they had to cater for this 'wasted energy' to make valves function before getting on with any 'real' design work.



Transistor inventors John Bardeen (L), William Shockley and Walter Brattain (R) in 1948.



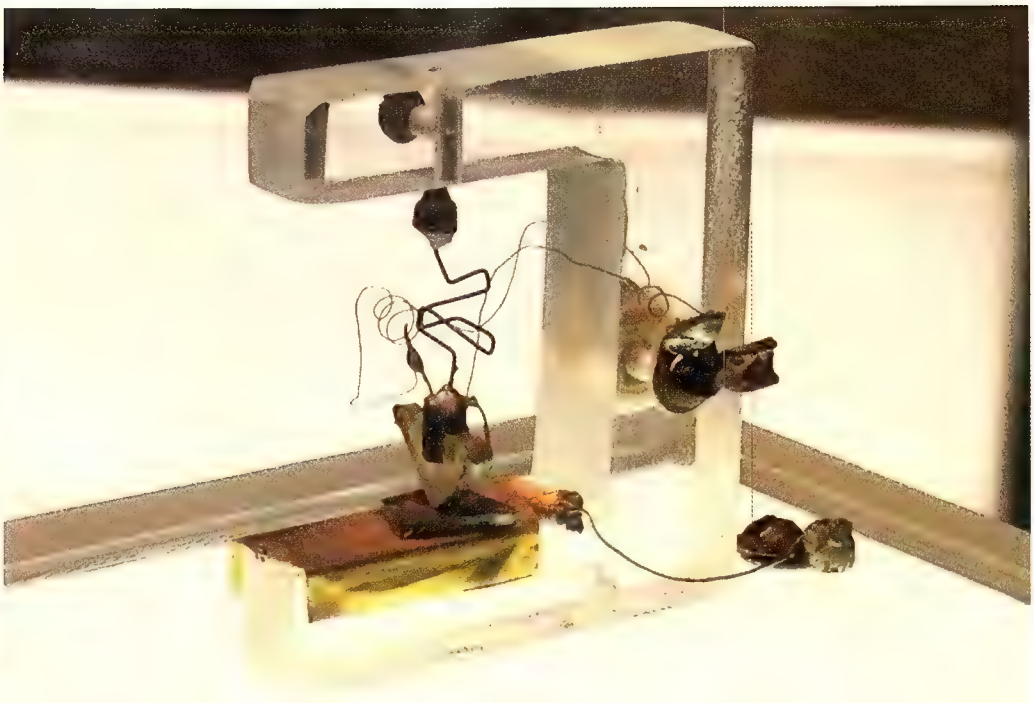
The NPN-type bipolar-junction transistor electrical symbol shows the Base (B) controlling the flow of electrical current between the Collector (C) and Emitter (E).

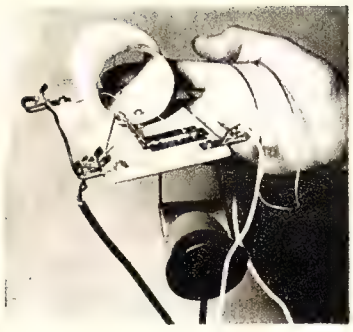
Portable? Not really...

Despite important pre-war Australian research into low-power valves, battle-field communications were still fraught during WWII. Even just the combination of valve's heating energy and insufficient portable power meant that while portable radio-telephones existed, most were limited, both in range and robustness. By war's end, the need to overcome this heat-energy requirement was now paramount. What's more, scientists already had a fair idea where the solution might come from.

The semi-conductor

Since the dawn of radio, one of the first electronic gadgets kids would build was a crystal radio set, so-called because it relied on a chunk of crystal galena or iron-pyrite to act as the important 'signal detector'. Crystal radios were also popular because they needed no power supply – the transmitted radio signal supplies all the power that is needed. During WWII, the amazing combination of a razor blade and graphite pencil was used to great effect as a signal-detector and many clandestine war-time radios were built in occupied territories, often at great risk to their owners. The key process that operated was the semi-conducting nature of the detector – in this case, it would allow electrical signals to flow in one direction, but not the other. This process stripped the radio-frequencies from the signal, leaving the audio that could be heard in a pair of high-impedance earphones. (We don't have space this month, but to understand some of the lengths Australian servicemen went to during WWII and the ingenuity they displayed, find





the incredible story of 'Winnie the War-Winner'.)

The periodic table of elements features a number with semi-conducting properties (Group IV), the two most common in electronics being Germanium (Ge) and Silicon (Si). Silicon was known as a semiconductor back in the 1900s and even in 1940, Russell Ohl, a scientist at the huge Bell Telephone Laboratories in the U.S. could make a block of silicon do 'strange' tricks. For example, by chemically treating a silicon block to feature two separated regions of electron charge (one positive, the other negative), Ohl saw that a voltage was developed by the block when light shined on the region divide or 'junction'. Today, this same principle now drives the solar-power industry.

The 'transistor'

By the end of the war, Bell Labs (Nokia Bell Labs today) was a huge hive of activity. It was where mathematical giants Alan Turing and Claude Shannon met during the war, it delivered pioneering work of Harry Nyquist (the Nyquist Sampling Theorem, used in digital electronics) and Ralph Hartley (the Hartley transform, used in signal processing). A research lab was set up to investigate the concept of 'solid-state' physics and by 1947, was home to research physicists John Bardeen, Walter Brattain and William Shockley. Although they succeeded in initial tests the previous week, it was on 23 December 1947 that Brattain and Bardeen demonstrated a small audio-amplifying circuit able to increase the power of an electrical audio signal by a factor of 18-times without a valve in sight.

But what was it that they'd created? This strange new component concept needed a snazzy name, so, Bell Labs used its collective genius, an in-house vote and six months later, Bell engineer John Pierce had struck gold with the name that has stuck ever since – the 'transistor'.

In fact, the scientists had developed what was eventually called the 'point-contact transistor', so called because it relied on the point-of-contact of two very close but electrically-isolated strips of gold in contact with a small piece of treated germanium block. A wire connection at the crystal was dubbed the 'Base', while the two gold strips were named 'Collector' and 'Emitter' respectively.

However, this point-contact mechanism meant these transistors were not only difficult to make, they were also less-than-rugged. Much like first-generation computers, point-contact transistors were manufactured, but they were soon obsolete and disappeared from the market by the mid-1960s.

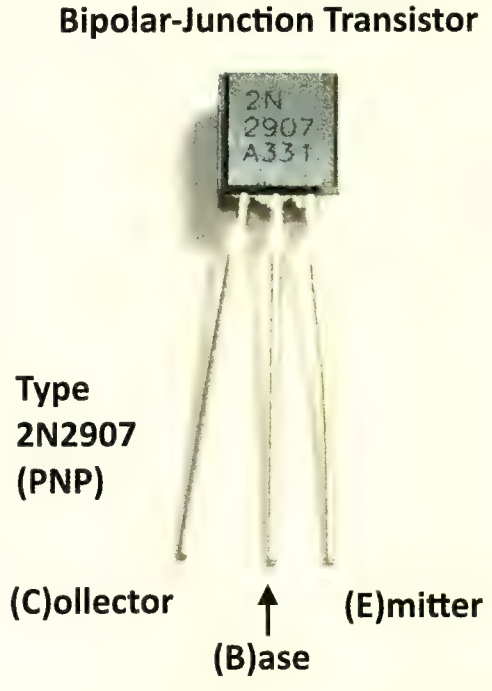
The 'bipolar-junction transistor'

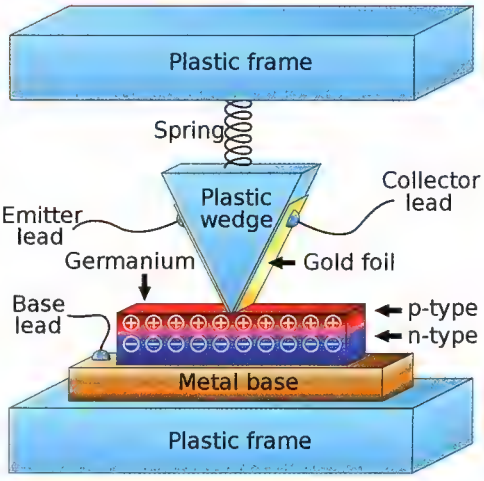
In fact, it was William Shockley who came up with a solution a few weeks later. He found that this same 'amplifying' principle could be observed by overlaying two junctions of positive- and negative-charged semiconductor material. It was called the 'bipolar-junction transistor' or 'BJT' in 1948.

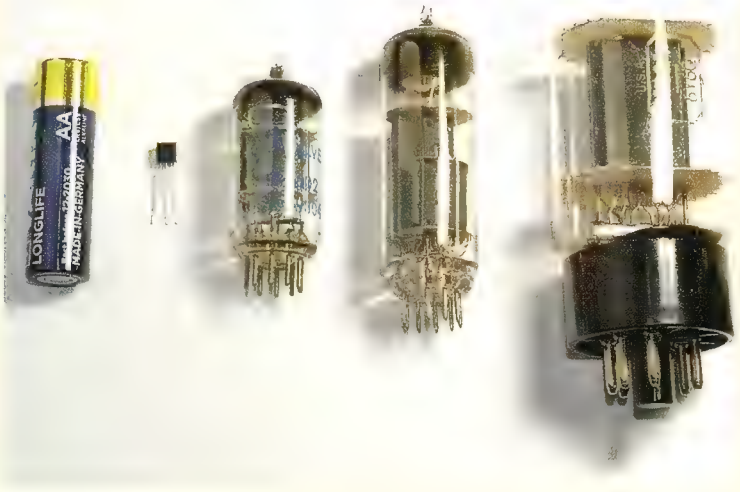
But even so, the question of just how you physically make a production transistor was a real head-scratcher – apart from it never having been done before, if it was going to replace the thermionic valve, you had to start making transistors do everything valves did. Valves were used in portable radios, but also radio transmitters, television – and some of these applications required a power rating of many tens, even hundreds of watts. The first low-power junction transistor didn't roll off production until 1951, and even then, engineers had to learn to new circuit designs to use them. But over the next two decades, transistors progressively replaced valves, although not everywhere – today, valves are still made for high-power/ frequency microwave communications and radar.

Above left: A WWII 'foxhole' radio made from a wire coil and razor blade with earpiece underneath.
Above: The first transistor from 1947 exhibited at Bell Labs (Image credit: Unitronic CC-BY-SA 3.0).

Below: Bipolar-junction transistors are still being made in their millions today (Image credit: Darren Yates)







Above left: The point-contact transistor used two isolated gold strips controlled by a treated germanium semiconductor base.
Above right: Transistors greatly benefited from miniaturisation (Image credit: Darren Yates).

The 1954 Regency TR-1

As a result, it's no surprise the first commercially-available transistor-powered consumer product was a new portable radio. Called the Regency TR-1, it launched in 1954 with transistors manufactured by U.S. giant Texas Instruments and reportedly cost US$50 at the time. The Australian electronics magazine we mentioned in Part 4 of this series, 'Radio & Hobbies', described how to build your own transistor radio in its July 1955 issue using new transistors from Philips. By 1956, the new 9V 'PP3' battery, much smaller than previous valve-era batteries and with lower capacity, began powering portable radios. These batteries were often dubbed 'transistor' batteries for this purpose and could provide up to 30 hours of use. Today, transistor radios keep MP3 players company in forgotten boxes of tech, but the PP3 battery lives on, driving smoke detectors around the country.

Metal-Oxide-Silicon Field-Effect Transistor

It's definitely a mouthful, but the MOSFET, invented at Bell Labs in 1959, has long become the workhorse of the electronics industry. Here, the 'Base' becomes 'Gate', 'Collector' becomes 'Drain' and 'Emitter becomes 'Source'. MOSFETs can be used as audio amplifiers, but they're far more at home as electronic switches, with the 'Gate' controlling whether the Source/Drain path is open or closed. This ability to act as a switch means MOSFETs are used in many applications where even modest amounts of electrical power has to be switched on and off – everything from cars to washing machines. But there is another popular application where electronic switches prove quite useful...

Why you cannot live without FinFETs

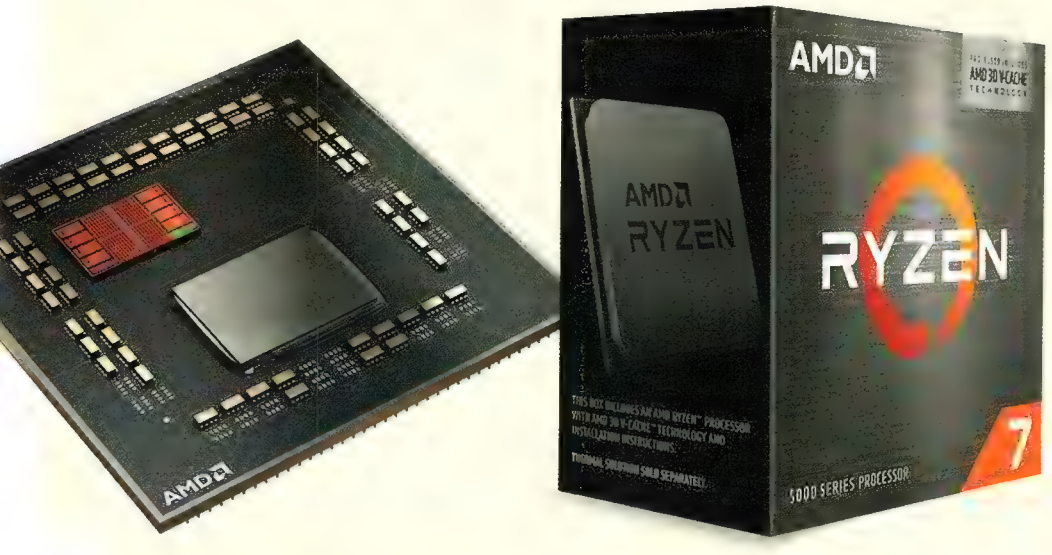
One of the most important modifications to the MOSFET is the 'Fin Field-Effect Transistor' or 'FinFET' for short. Whereas previous generations of transistor were essentially built up in sandwich-like layers, the FinFET is a three-dimensional (3D) construct where the main source/drain connections form wings or 'fins' on the silicon base or 'substrate'.

Yes, it sounds all a bit geeky and if that doesn't impress you, here's something else that might – your favourite computing device's CPU (doesn't matter which) is filled to the brim with these amazing components. For instance, Apple's new A16 Bionic chip inside the iPhone 14 claims to have an astounding 16-billion transistors (almost). When you consider the number of chips being made, the number of transistors being manufactured globally is truly mind-boggling.

Made in Australia

Throughout this series, we've seen the importance placed at the time in Australia of locally-producing our own technology, from the launch of Amalgamated Wireless Valve (AWV) in 1933 and it Ashfield factory in Sydney's inner-west to the making of our own radar equipment during the war.

Again, it shouldn't surprise that the Commonwealth Scientific and Industrial Research Organisation (CSIRO), whilst in the middle of maintaining Australia's first computer (CSIRAC, Part 5) and



AMD's upcoming Ryzen 7000-series CPUs is said to have more than 6.5-billion transistors.

pioneering radio-physics research (Parts 6 and 7), also found time to research semiconductors at a new facility in Rydalmere in Sydney's west from 1953. The first transistors manufactured in Australia were produced in 1958 by British firm Standard Telephone and Cables (STC). AWV began making transistors from Radio Corporation of America (RCA) in 1959, while Dutch giant Philips made its own transistors at its big new Hendon factory in South Australia the same year. Another maker, Ducon, licensed and built transistors from France in 1960, while the U.S. giant Fairchild built a local factory in Melbourne in the mid-1960s. But by Christmas 1973, the Australian government had slashed the tariffs on imported electronics with little transition period, leaving many local electronics manufacturers unprofitable in short time. Apart from some research areas, the bulk of Australia's semiconductor operations moved overseas – but as we'll soon see, it's not where the story ends.

The future goes GAA-GAA

If you're reading APC, you know that technology never sits still and transistor development is at the very heart of technology design. As you read this, Intel, TSMC and Samsung are testing production of new chips built around equally-new Gate-All-Around Field-Effect Transistors (GAAFETs). Samsung's version announced in June 2022 is known as 'Multi-Bridge-Channel FET'. These transistors are made with a lithographic process where the key minimum measurement is just three-nanometres (3nm) wide and will almost certainly take over as the transistor-of-choice for most new CPU designs.

What makes the GAAFET so important is it allows chip designers to customise power/performance trade-offs right down to the individual transistor – and they'll eventually appear in everything from smartphones to data centres.

A great hobby awaits

So after all that, it's no stretch to say transistors power the world, yet they were also the start for many (including me) into the fascinating world of electronics. As we've also seen, building your own technology has a long and proud history in Australia and while some may lament its apparent passing in favour of more modern pursuits, any lament is still somewhat misplaced. Today, bipolar-junction transistors sell for as little as 30 cents each at Jaycar and Altronics stores, among many other components – and there are many resources to teach you how they all work. As our consumer-driven world grows ever more disposable, building your own tech gadgets that you can modify, repair and re-use teaches you valuable skills, from the technology itself to problem-solving.

Smoke-alarm batteries were originally called 'transistor' batteries to power portable radios (Image credit: Joe Haupt, CC-BY-SA 2.0)

The beginning – and the end

Despite its slow beginnings, the transistor has become a fundamental cog in modern life, the ways it has changed are lives are innumerable. Yet in many regards, it's still only the beginning. Australia remains at the forefront of research into quantum computing and although quantum computers typically compute states at an atomic level, semiconductors such as silicon continue to play a crucial role in new research. In June 2022, former Australian of the Year Professor Michelle Simmons and the team at Silicon Quantum Computing (a start-up of the University of NSW) simulated the atomic structure of polyacetylene, an organic compound, using a chain of 10 quantum dots controlled by a series of MOSFET-like gates made from silicon semiconductor. It's a breakthrough that will allow scientists greater understanding of how nature operates and functions at atomic levels.

The basic thread we've weaved throughout this series is humankind's ability to control a large electrical current using a smaller one – and it's enabled everything from music to radar, computers to space communications. This capability was first supplied by the thermionic valve, but now for 75 years, the transistor truly has been the technology that continues to change Australia and the world.

(While it might still be the beginning for the transistor, it is the end for this series, hope you enjoyed it. If you'd like to see more like this in the future, drop us a line at apcmag@futurenet.com.) ■

The world's first transistorised portable radio, the Regency TR-1 (Image credit: Cmglee, CC-BY-SA 3.0).

Upgrade your PC FOR FREE

Don't pay for expensive new components to improve the performance of your PC. Robert Irvine explains how to tweak your system to make old hardware run as good as new.

WHAT YOU CAN DO

- Increase the amount of available memory on your PC
- Stop your browser hogging system resources
- Check if you can overclock your processor
- Boost the performance of your graphics card
- Free up space by compressing your hard drive
- Optimise your monitor's screen settings
- Improve the audio quality of your sound card

When your PC starts slowing down, hanging when performing everyday tasks or displaying distorted images, it's logical to conclude that you may need to upgrade its memory, processor or graphics card. Although replacing a failing component is cheaper than buying a new PC, it's still an expensive and confusing task.

First you need to ensure that any new kit you install is compatible with your existing hardware. This involves carefully inspecting specifications and shopping around for the best deal – expect to pay between $50 and $80 for an extra 8GB of RAM, from $250 for a new processor and at least that amount for a basic graphics card. You then need to go through the hassle of removing your PC's case and fiddling with its insides – which may not even be possible with a laptop. Although some upgrades are straightforward – for example, memory modules can usually be slotted right in – others, such as replacing a CPU or motherboard, are more delicate and risk damaging rather than enhancing your computer.

Thankfully, you can fix many problems with your system without resorting to pricey and tricky physical upgrades. By tweaking default settings, unlocking hidden options and installing powerful third-party tools, you can effectively upgrade your PC for free. And while the hacks we suggest aren't a direct substitute for installing new components, they can make your old hardware run as good as new.

FREE UP SYSTEM MEMORY

Reclaim memory from background processes

Windows is supposed to manage memory usage on your PC automatically, by switching to virtual memory when you run out of physical RAM, and by freeing up memory from inactive programs. But if you open Task Manager (by pressing Ctrl-Shift-Esc) and look at the Memory column, you'll see there are plenty of processes currently using RAM in the background. Some of these are likely to be tools you recently closed, never opened or don't even recognise, but which are cumulatively consuming a significant amount of available memory.

Rather than let your PC slip into slower virtual memory, you can reclaim RAM using Wise Memory Optimizer (**www.wisecleaner.com/wise-memory-optimizer.html**). This free program displays a pie chart showing you how much memory is in use and how much is available. Click its Optimize button (1 in our screenshot above right) – or right-click its taskbar icon and choose Optimize – to free up as much RAM as possible from background processes.

You can also optimise memory automatically by clicking the Settings cog and ticking Auto Optimization 2. Decide whether to release RAM when available memory falls below a certain threshold or to do so at regular intervals, and set the tool to run when Windows starts to prevent freezes and crashes.

Wise Memory Optimizer reduced our PC's memory usage from 95 per cent to 48 per cent 3, though this gradually crept back up to 66 per cent. We confirmed these figures by checking Task Manager.

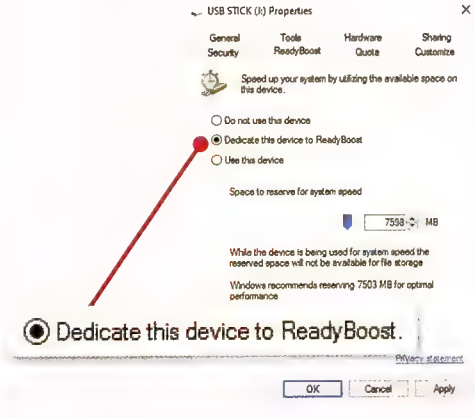
Wise Memory Optimizer automatically frees up RAM to stop your PC hanging and crashing.

Increase your PC's memory with a USB stick

If your PC often struggles with resource-heavy activities such as gaming and video editing, you can increase its memory (temporarily) using a Windows feature called ReadyBoost and a spare USB stick or SD card. Your system treats the removable storage as extra RAM, so it can perform intensive tasks more efficiently, though only if your main system drive is a traditional hard drive. ReadyBoost won't work with SSDs, which are fast enough to provide speedy virtual memory, but it can help improve the performance of older PCs (you can also use it in new computers running Windows 11).

To use ReadyBoost, insert a USB stick or SD card in the relevant port or slot, then open This PC in File Explorer and right-click the card or stick's icon. Select 'Format', choose 'NTFS' in the 'File system' dropdown menu and click Start. Once formatting is complete, right-click the drive icon again, choose Properties and click the ReadyBoost tab. Select the option 'Dedicate this device to ReadyBoost' (see screenshot below left), specify how much space to allocate to the feature and click OK.

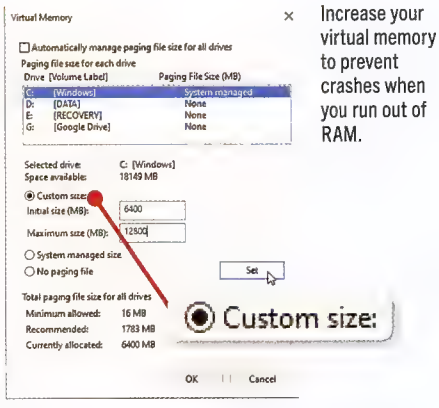
ReadyBoost relies on your USB stick or SD card remaining plugged in – as soon as you disconnect it, you'll lose the memory boost.



ReadyBoost lets you use a spare USB stick to improve your PC's memory.

Adjust your PC's virtual memory

As mentioned above, when insufficient RAM is available, Windows temporarily saves data to an area of your hard drive called virtual memory – also known as the 'paging file'. But if your PC runs out of both real and virtual memory, it will crash – which is something you obviously want to avoid. The paging file is also important for creating 'memory dumps' that tell you what caused the crash. Windows should warn you when you're low on virtual memory, and



Increase your virtual memory to prevent crashes when you run out of RAM.

adjust the paging file accordingly, but if you often run out of RAM it's worth increasing its size manually to prevent errors and crashes.

In Windows 10 or 11, press Windows key-I to open Settings. Choose 'System' then About and click 'Advanced system settings'. Click the Advanced tab, then the Settings button under Performance and click the Advanced tab there. Click 'Change' under 'Virtual memory' and untick 'Automatically manage paging file size for all drives'.

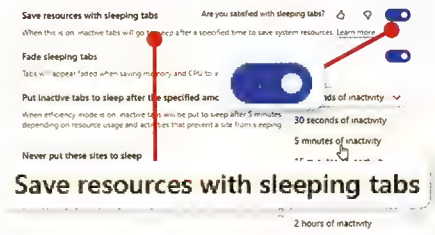
Select 'Custom size' (see screenshot above) to increase the paging-file size for your main hard drive (usually your C: drive). Enter the 'Initial size' (the same amount that Windows has currently allocated) and a 'Maximum size' – this can be up to three times your amount of physical RAM, but double should be enough. Click 'Set' then OK to confirm. If you have any problems, re-enable the 'Automatically manage' option.

Reduce your browser's memory usage

Your web browser is almost certainly the biggest memory hog on your PC and, because you can't do without it, often the main reason for upgrading your RAM. This is particularly true of Chrome, which uses a separate

background process for every tab, plug-in and extension. Windows' Task Manager doesn't tell you which Chrome process relates to which element, so you can't simply close the one that's using the most memory, though you can get this information from the browser's own Task Manager – select 'More tools' in Chrome's main menu to access this.

In Microsoft Edge, you can reduce memory usage through a handy feature called Sleeping Tabs, which releases RAM from inactive tabs so it can be used by other processes. To activate it, click the browser's three-dot menu button and choose Settings then 'System and performance'. In the 'Optimise performance' section, switch on 'Save resources with sleeping tabs' (see screenshot above right), then click the dropdown menu next to 'Put inactive tabs to sleep after the specified amount of time' and choose a waiting time, from 30 seconds of inactivity to 12 hours. Clicking a sleeping tab will wake it up again. Microsoft claims Sleeping Tabs reduces Edge's memory usage by an average of 32 per cent.


Save resources with sleeping tabs
Are you satisfied with sleeping tabs?
Fade sleeping tabs
Put inactive tabs to sleep after the specified amc
30 seconds of inactivity
5 minutes of inactivity
Never put these sites to sleep
Save resources with sleeping tabs
2 hours of inactivity

Edge's Sleeping Tabs feature automatically frees up memory from inactive tabs.

Firefox has a less sophisticated feature called Tab Unloading, which automatically puts tabs to sleep when system memory is slow to prevent the browser from crashing. You can manually unload your least recently used tabs by typing about:unloads, pressing Enter and clicking the Unload button. It's also worth typing about:memory and clicking the 'Minimize memory usage' button to free up RAM from Firefox.

Chrome has yet to introduce a proper memory-saving feature, though you can unload and reload tabs by going to **chrome://discards**. A better option is to install the Tab Suspender extension (**www.snipca.com/43247**), which automatically releases RAM from unused tabs after a specific period of inactivity – or manually when you click 'Suspend: Tab' (see screenshot above) – and lets you restore them with a single click. We use this tool on our own PC to reduce memory usage and prevent Chrome from freezing when we have multiple tabs open.

Tab Suspender boosts your available RAM by suspending unused Chrome tabs.

SPEED UP YOUR PC's PROCESSOR

Stop programs hogging your processor

Your PC's processor has multiple cores – for example, a quad-core CPU has four – and Windows decides which processes are assigned to each one. Resource-hungry software such as video editors and web browsers often uses multiple cores, which leaves other tools competing for processing power and slows down the overall speed of your PC. Rather than upgrade your CPU, you can try to fix this by adjusting your processor's 'affinity'. This allows you to assign specific cores to demanding programs so they run as efficiently as possible without hogging system resources.

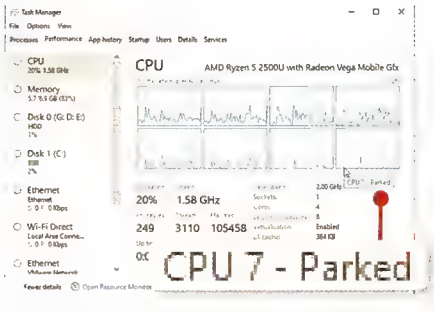
First, you should check which cores are currently underutilised. Open Task Manager in Windows 10 or 11 by pressing Ctrl-Shift-Esc and click the Performance tab. In the CPU section, right-click the graph and choose 'Change graph to' then 'Logical processes'. This will display separate graphs for each of your processor cores – hover your mouse over one to see its core number. Cores that currently have little activity – such as CPU 7 in our screenshot below left – are ideal for devoting to resource-hungry programs.

Next, click the Details tab in Task Manager, right-click a greedy process and choose 'Set affinity'. Untick the All Processors box and select one or two cores (see screenshot below) to assign the program to. Click 'OK' to confirm and the program will now only run on the selected CPU core(s), which should free up processing power for other tools.

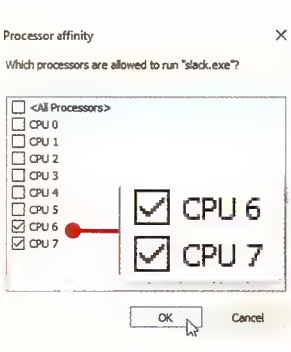
Disable unnecessary effects

Many features enabled by default in Windows 10 and 11 are supposed to enhance your user experience, but also require processing power that would be better dedicated to more important tasks, especially on older PCs. For example, are you really bothered about your desktop icons having shadows or whether window menus slide into view? If not, you can turn off unnecessary visual effects to improve system performance.

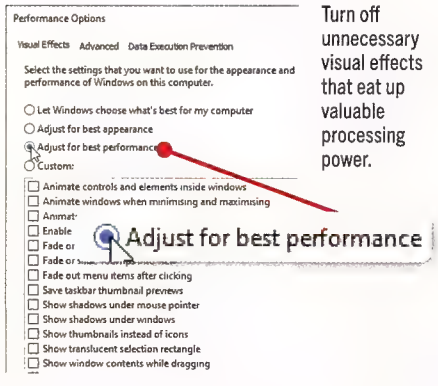
Press the Windows key-R to open the Run box, type sysdm.cpl then press Enter. When the System Properties box opens, click the Advanced tab then the Settings button under Performance. On the Visual Effects tab, select 'Adjust for best performance' (see screenshot below)



Task Manager will tell you which CPU cores currently have the least activity.



Choose which processor cores to devote to resource-hungry programs.


Performance Options
Visual Effects
Advanced
Data Execution Prevention
Select the settings that you want to use for the appearance and performance of Windows on this computer.
Let Windows choose what's best for my computer
Adjust for best appearance
Adjust for best performance
Custom:
Animate controls and elements inside windows
Animate windows when minimising and maximising
Enable
Fade out menu items after clicking
Save taskbar thumbnail previews
Show shadows under mouse pointer
Show shadows under windows
Show thumbnails instead of icons
Show translucent selection rectangle
Show window contents while dragging
Adjust for best performance

Turn off unnecessary visual effects that eat up valuable processing power.

to disable all visual effects, then click Apply or OK. You can always re-enable specific effects if you miss them.

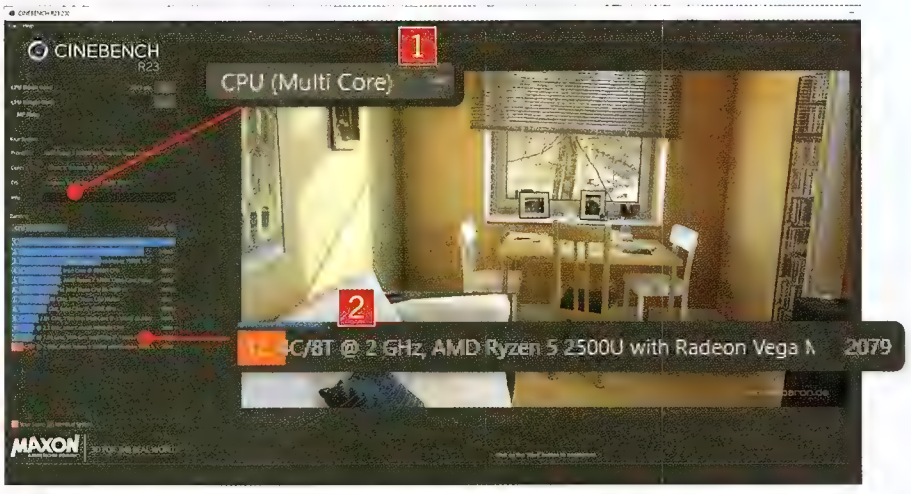
It's also worth turning off the transparency effects Windows applies to your Start menu, taskbar and Action Centre – as well as folder and program windows in Windows 11 – as these use a small but significant amount of CPU power. Right-click your desktop, choose Personalise then Colours, and disable the 'Transparency effects' option.

Check if you can overclock your processor

The most drastic way to boost your processor's speed without upgrading is to 'overclock' it, which means to increase its clock rate and/or voltage to exceed that set by the manufacturer. The benefit is that you get a faster CPU that can perform more operations per second, but overclocking can also cause your processor to overheat and damage your hardware, as well as void your warranty. You may not even be able to overclock, if your motherboard or CPU has been locked by the manufacturer. But if you're determined to try, there are precautions you can take to ensure your PC doesn't malfunction.

First, you should check your processor's current temperature to make sure it isn't already too hot. Download HWiNFO from **www.snipca.com/42747**, launch the tool and click 'Sensors only'. Click 'Start' then scroll down the table of results to the Core Temperatures entry.

Ideally your CPU cores should be between 40 and 65 degrees Celsius – if they're hotter than 75°C, you shouldn't risk overclocking.



Test your processor using Cinebench to see how it compares with others.

Next, perform a 'stress test' to check that your processor is stable and not prone to overheating at its default clock speed. Download the free tool Prime95 from **www.snipca.com/43272**, extract the contents of the ZIP file and double-click the 'prime95.exe' file – click 'More info' then 'Run anyway' if you see a Microsoft Defender SmartScreen warning. When Prime95 opens, click Just Stress Testing then OK to run a 'torture test'.

This pushes your processor to its limit by performing an intensive stream of complex mathematical computations until an error occurs, at which point the tool will stop. Leave Prime95 running for a few hours to perform a thorough test, but be warned that your PC may get noisy as its fans spin faster to keep it cool – click Test then Stop to end the test. If Prime95 fails to detect any errors, then your processor should be stable enough for overclocking.

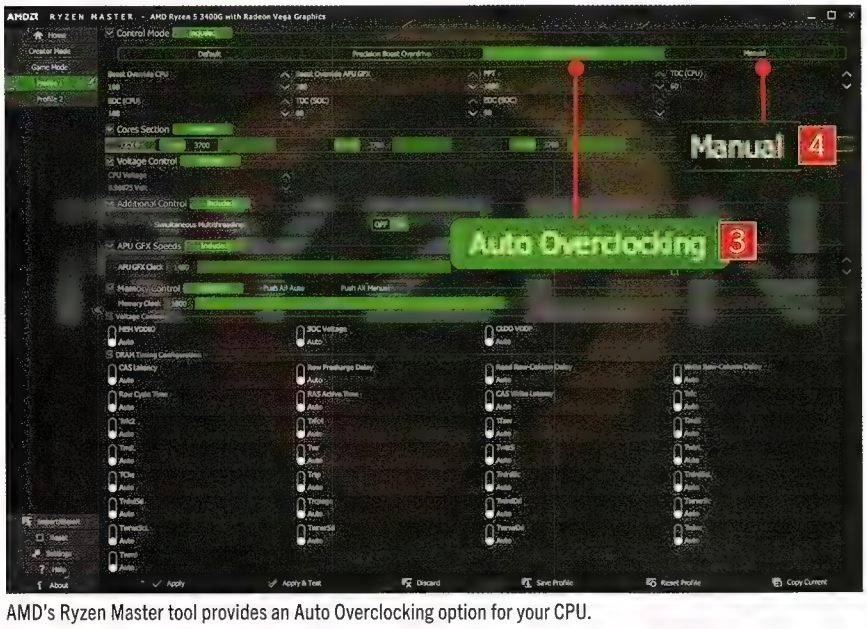
It's also useful to benchmark test your CPU before and after you overclock it, to see if the tweaks you make improve or impair its performance. Download Cinebench from **www.snipca.com/43274** and run its CPU (Multi-Core) test (1 in our screenshot above). This evaluates how well your processor copes with rendering a detailed 3D image, then gives it an overall score. Look at the chart in the bottom-left corner to find out how your CPU compares with processors in similar systems – ours scored 2,079 points, which ranked last in the comparison 2, so we have plenty of room for improvement.

Once you've performed these checks, you can try overclocking your processor. Although you can overclock manually by tweaking settings in your PC's BIOS or UEFI – press F2 or F10 while booting to access this – the safest method is to use a tool from your CPU's manufacturer.

For AMD processors, download Ryzen Master (**www.snipca.com/43277**), which offers both Auto Overclocking (3 in our screenshot left) and Manual options 4.

For Intel processors, install the manufacturer's Extreme Tuning Utility (**www.snipca.com/43276**) and change settings in the Advanced Tuning section.

Our sister title *PC Gamer* provides a detailed guide to overclocking an AMD Ryzen processor, both manually and automatically (**www.snipca.com/43278**) as well as one for Intel CPUs (**www.snipca.com/43279**). Note that if your processor doesn't support overclocking, you won't be able to install the official manufacturer's tool.



AMD's Ryzen Master tool provides an Auto Overclocking option for your CPU.

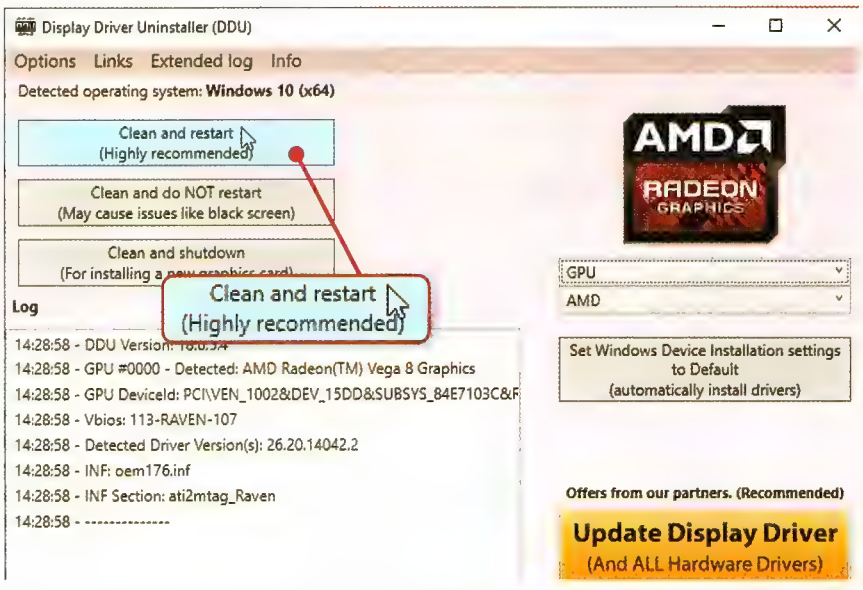
OPTIMISE YOUR GRAPHICS CARD

Perform a clean install of graphics drivers

It's essential to have the latest drivers installed for your graphics card, and to ensure they're sourced from the manufacturer rather than generic drivers. Instead of using Windows Update, you can download Nvidia drivers from www.snipca.com/42961, AMD drivers from **www.snipca.com/42962** and Intel drivers from **www.snipca.com/43283**, but for optimum performance it's wise to perform a clean install rather than just upgrade from the previous drivers.

A free tool called Display Driver Uninstaller will thoroughly remove old Nvidia, AMD and Intel graphics drivers from your system, including registry keys, driver store packages and redundant files. Download it from **www.snipca.com/43281**, extract the contents of the ZIP file and open the DDU folder. Drag the Display Driver Uninstaller EXE file to your desktop and reboot your PC into Safe mode – you can use the tool in normal mode but it may not work as effectively. Double-click the EXE file to launch the program and select GPU in the 'Select device type' dropdown menu. Display Driver Uninstaller will automatically detect which graphics drivers you have installed. Click the Options button and ensure 'Create a system restore point' is selected, then click 'Clean and restart' (see screenshot).

Display Driver Uninstaller will now remove all traces of your current graphics drivers, which means your screen resolution may change. Once your PC restarts, you can cleanly install your graphics card's new drivers from the manufacturer.


Display Driver Uninstaller (DDU)
Options Links Extended log Info
Detected operating system: Windows 10 (x64)
Clean and restart (Highly recommended)
Clean and do NOT restart (May cause issues like black screen)
Clean and shutdown
Log
14:28:58 - GPU #0000 - Detected: AMD Radeon(TM) Vega 8 Graphics
14:28:58 - Vbios: 113-RAVEN-107
14:28:58 - Detected Driver Version(s): 26.20.14042.2
14:28:58 - INF: oem176.inf
14:28:58 - INF Section: ati2mtag_Raven
14:28:58 - ----------
AMD RADEON GRAPHICS
GPU
AMD
Set Windows Device Installation settings to Default (automatically install drivers)
Offers from our partners. (Recommended)
Update Display Driver (And ALL Hardware Drivers)

Display Driver Uninstaller removes old graphics drivers so you can cleanly install new ones.

If a clean install sounds too drastic, you can try rebooting your graphics drivers instead by pressing Windows key-Ctrl-Shift-B. Your screen will flicker and go black for a few seconds, and you'll hear a beep, after which your drivers will be restarted.

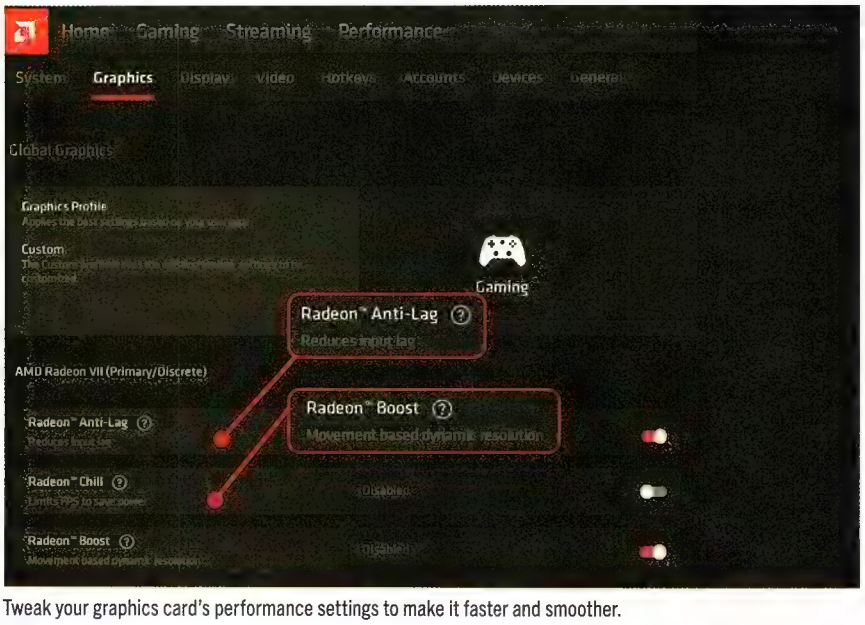
Tweak your graphics card's performance settings

Your graphics card's default settings will balance picture quality, performance and power consumption, but if you're using a desktop PC or mains-connected laptop you can sacrifice the latter to improve how quickly and reliably it displays games and videos.

You can access your GPU settings via the Start menu or by right-clicking your desktop and choosing Nvidia Control Panel, AMD Radeon Settings or Intel Graphics Settings. If you have an Nvidia graphics card, select Manage 3D Settings and click the Global Settings tab. Click the 'Power management mode' dropdown menu and select 'Prefer maximum performance'. Next, set 'Texture filtering – Quality' to 'High performance'. Click 'Apply' to save the new settings.

With an AMD graphics card, click the Gaming tab and choose Graphics, then Standard. Switch on the options Radeon Anti-Lag and Radeon Boost (if available – see screenshot above), then click Advanced and set the Texture Filtering Quality option to Performance.

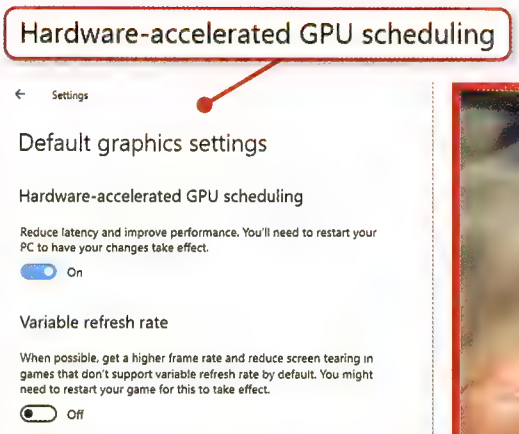
Intel only lets you adjust performance settings for specific games – select a game in its Graphics Command Centre then click Performance.



Tweak your graphics card's performance settings to make it faster and smoother.

Switch on hardware-accelerated GPU scheduling

Windows 10 and 11 offer a feature called hardware-accelerated GPU scheduling, which instructs your graphics card to use the optimum amount of power depending on what you're doing. It moves visual and graphics-intensive data from your CPU to the GPU and is


Hardware-accelerated GPU scheduling
Settings
Default graphics settings
Hardware-accelerated GPU scheduling
Reduce latency and improve performance. You'll need to restart your PC to have your changes take effect.
On
Variable refresh rate
When possible, get a higher frame rate and reduce screen tearing in games that don't support variable refresh rate by default. You might need to restart your game for this to take effect.
Off

Check if your graphics card supports hardware-accelerated GPU scheduling to improve its performance.

particularly useful when playing games and streaming videos. However, the option is disabled by default and only available if your graphics card is an Nvidia GTX (1000 or later) or AMD (5600 series or later) model.

If your GPU qualifies, press the Windows key-I to open Settings and click System, then Display. In Windows 10, choose 'Graphics settings' under 'Multiple displays'; in Windows 11, select Graphics then 'Change default graphics settings'. Switch on 'Hardware-accelerated GPU scheduling' (see screenshot above), restart your PC and you should notice an improvement in your graphics performance.

Overclock your graphics card

Overclocking your graphics card can improve its performance by as much as 15 per cent and provide smoother, sharper graphics. It's safer than overclocking your CPU because GPUs have failsafe mechanisms that kick in before they overheat. It's also much easier to do by either tweaking settings in your graphics card's software or using an excellent free tool called MSI Afterburner, which works with all makes of GPU.

Download the program from **www.snipca.com/43284**, then extract, install and launch it. MSI Afterburner will instantly display information about your graphics card's speed, voltage, temperature and more. To overclock your GPU, simply click the OC Scanner button on the left – this looks like a magnifying glass and a C (see screenshot below), but if you can't see it then your graphics card may not be compatible with the program. Click 'Scan' and the program will automatically detect, test and apply what it considers the best possible settings for your graphics card.

CLEAN THE INSIDE OF YOUR PC WITHOUT DAMAGING IT

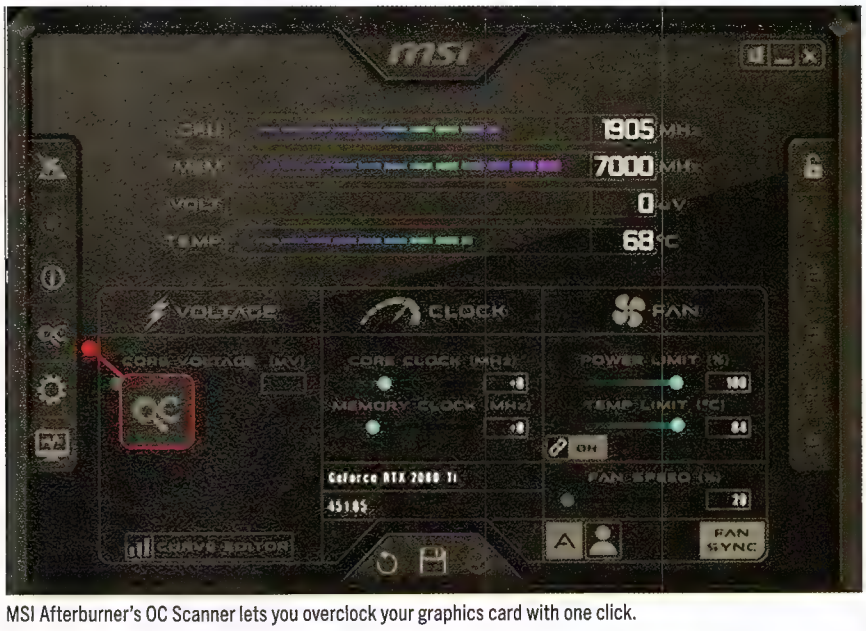
When dust, dirt and hair get into your PC, it's forced to work harder, which means its overall performance will suffer. At least once a year, it's a good idea to give the insides of your machine a thorough clean, which may save you needing to upgrade individual components. Always perform the following tasks with your PC switched off and unplugged from the mains.

First make sure all your PC's fans are working properly and that the ventilation holes in the case aren't clogged with muck. Use a can of compressed air to remove any grime.

Use a stiff paint brush or old toothbrush to clean the fan blades and the inside of your case. Take care because the components are fragile and expensive to replace. Spray the inside of the case with the compressed air, but be warned that this can generate a lot of dust so you may want to do it outside or in a well-ventilated area. Make sure you blow the dust out of your case and not further into it – if provided, insert the extension straw into the can's nozzle (as pictured) to get into nooks and crannies. Use a soft cloth to wipe your graphics card and the floor of the case, but be careful not to damage delicate components such as your motherboard.

Alternatively, you can use the sliders to manually increase GPU settings such as clock speed. You can unlock greyed-out options by clicking the Settings button and selecting, for example, 'Unlock voltage control'. When you've finished tweaking, click Apply then Save, or choose Reset to restore your default settings.

MSI Afterburner also lets you customise how it looks – choose Settings, then User Interface and select a different skin from the dropdown menu.



MSI Afterburner's OC Scanner lets you overclock your graphics card with one click.

FREE UP SPACE ON YOUR HARD DRIVE

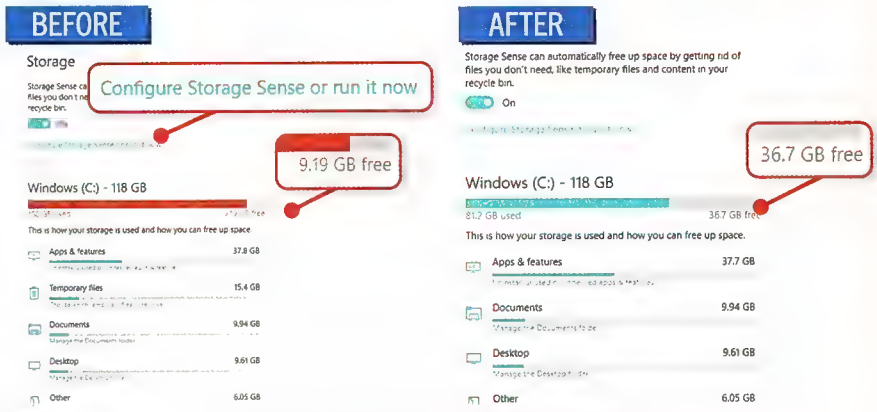
Remove junk files from your hard drive

The Storage Sense feature in Windows 10 and 11 automatically removes junk files that are taking up space on your hard drive, but you can also run it manually.

Open Settings and click System followed by Storage. Here you'll see a breakdown of what's taking up space on your PC. Switch on Storage Sense if it isn't already active then click 'Configure Storage Sense or run it now' in Windows 10 (see screenshot), or just Storage Sense in Windows 11. Specify how frequently you want to purge your PC of temporary files and old files in your recycle bin and Downloads folder. For an instant clean-up, click 'Clean now' in Windows 10 or Run Storage Sense Now in Windows 11.

Click back to the Storage screen and select 'Temporary files'. This section goes further than Storage Sense by letting you delete space-hogging junk such as old Windows Updates and driver packages, memory dump files and thumbnails for photos, videos and documents. Select the items to delete and click 'Remove files'.

Back on the Storage Screen, explore the other categories such as 'Apps & features' (called 'Installed apps' in Windows 11), Documents and Other to identify and remove further space hogs. Windows 11 helpfully provides 'Cleanup recommendations' based on large apps and files you don't use, which can save you a bit of time. Once you've deleted all unwanted junk, you should have several gigabytes of extra storage – we increased our free drive space from 9.2GB to 36.7GB (see screenshots) through manual removal, gaining 27.5GB.


BEFORE
Storage
Configure Storage Sense or run it now
9.19 GB free
Windows (C:) - 118 GB
Apps & features 37.8 GB
Temporary files 15.4 GB
Documents 9.94 GB
Desktop 9.61 GB
Other 6.05 GB
AFTER
Storage Sense can automatically free up space by getting rid of files you don't need, like temporary files and content in your recycle bin.
On
36.7 GB free
Windows (C:) - 118 GB
81.2 GB used
This is how your storage is used and how you can free up space.
Apps & features 37.7 GB
Documents 9.94 GB
Desktop 9.61 GB
Other 6.05 GB

We freed up 27.5GB of drive space by deleting files through Windows 10's Storage screen

Compress large drives and partitions

Windows lets you compress drives (including SSDs) and partitions on your PC to shrink their size and free up space – often many gigabytes worth. Unlike ZIP files, compressed drives don't require you to extract their contents to access files, because the NTFS compression – and decompression – process is handled in the background. This means you can browse compressed drives in File Explorer in the usual manner, though files may take longer to open.

To compress a drive or partition, right-click it in the This PC section of File Explorer and choose Properties. On the General tab, select 'Compress this drive to save disk space' (see screenshot below left) then click Apply. Choose 'Apply changes to drive, subfolders and files' and click OK. Click 'Continue' if prompted to provide administrator permission and the drive or partition will be compressed. This can take a while, depending on its size and contents.

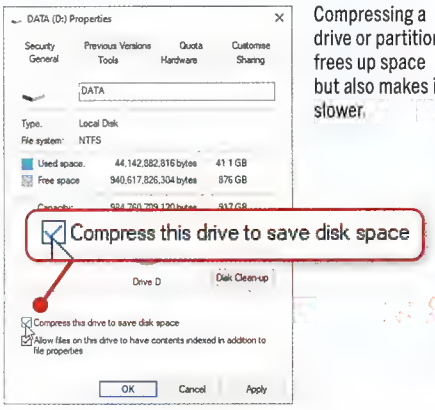
If you find the compressed drive or partition too slow – especially if it's your main system drive – untick the 'Compress this drive...' option then click Apply.

Switch off Hibernate to free up space

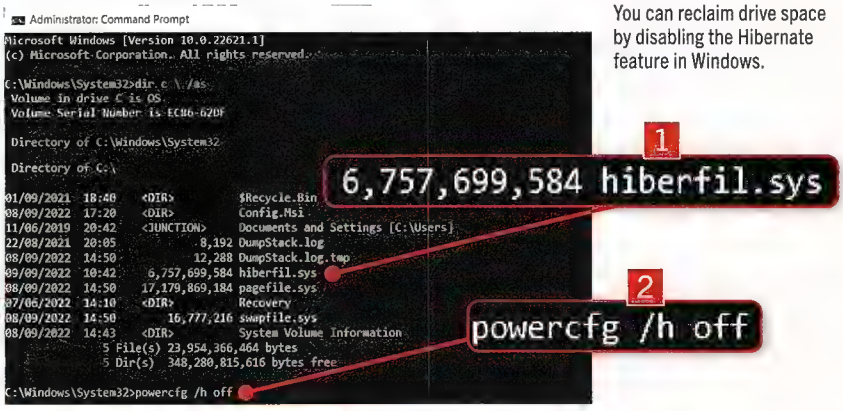
The Hibernate feature in Windows conserves power when your PC is idle by copying everything in its memory to a file called 'Hiberfil.sys', then powering down your system. When you turn your PC back on, Windows quickly loads all the data from the saved file. However, if you don't leave your PC constantly running when you're not using it, you have an SSD (which uses less power than a mechanical drive) or you're happy to rely on Sleep mode instead, the 'Hiberfil.sys' file simply wastes valuable space.

To find out how much space Hibernate uses, type **cmd** in the Windows search box and choose 'Run as administrator' under Command Prompt. When Command Prompt opens, type the following command and press Enter: **dir c:\/as** (replace 'c:\' with your main drive's letter if different). Look at the 'hiberfil.sys' line to see the amount of storage the file consumes – nearly 6.8GB on our PC (1 in our screenshot below).

To switch off Hibernate and free up space, type **powercfg /h off** into Command Prompt 2 and press Enter. You won't see confirmation that Hibernate is disabled, but you can check by typing powercfg /a and pressing Enter. You can turn it back on again by typing powercfg /h on into Command Prompt.



Compressing a drive or partition frees up space but also makes it slower.



You can reclaim drive space by disabling the Hibernate feature in Windows.

FIX PROBLEMS WITH YOUR MONITOR

Display Colour Calibration
How to adjust brightness
adjust brightness
The brightness adjustment determines how dark colours and shadows appear on your display.
When adjusting the brightness on the next page, try to get the image to look like the sample image labelled Good brightness below.
Too dark
Good brightness
Too bright

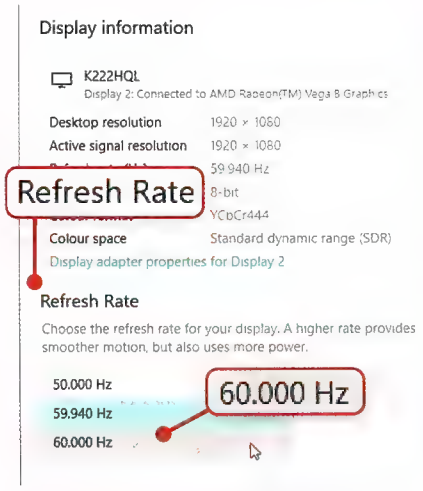
Calibrate your monitor to fix problems with colour, brightness and contrast.

Calibrate your monitor

Windows includes a Display Colour Calibration tool you can use to improve your monitor's display quality and potentially fix problems.

To use it, type calibrate into the Windows search box and select 'Calibrate display colour'. If you have more than one monitor attached to your PC, drag the calibration window to the one you want to adjust. Click 'Next' and follow the on-screen instructions.

The tool lets you tweak your monitor's gamma (the relationship between red, green and blue colour values), brightness and contrast (see screenshot above right), and colour balance, as well as turning on ClearType to make text easier to read.


Display information
K222HQL
Display 2: Connected to AMD Radeon(TM) Vega 8 Graphics
Desktop resolution 1920 × 1080
Active signal resolution 1920 × 1080
59.940 Hz
8-bit
YCbCr444
Colour space Standard dynamic range (SDR)
Display adapter properties for Display 2
Refresh Rate
Refresh Rate
Choose the refresh rate for your display. A higher rate provides smoother motion, but also uses more power.
50.000 Hz
59.940 Hz
60.000 Hz
60.000 Hz

Increasing your monitor's refresh rate may stop your screen flickering .

Updating the drivers for your monitor and graphics card can also solve problems with colour and vertical or horizontal lines across your screen.

Adjust your refresh rate

Increasing the refresh rate of your monitor can result in much smoother visuals, and stop your screen flickering. In Windows 10 or 11, open Settings and choose System, then Display. Click the 'Advanced display settings' link and select a different refresh rate in the dropdown menu (see screenshot below).

The options available will depend on the make and model of your screen (it's possible you won't be able to change from the default), but try increasing the refresh rate, which is measured in hertz (Hz) – how many times per second your monitor is able to draw a new image – to see if it fixes your display problem.

Flickering and stuttering (when your screen goes black) can also be caused by a faulty monitor cable so make sure yours is connected securely. If you have a spare VGA/HDMI cable, try using that instead.

Fix stuck pixels

Stuck pixels – which look like red, green or blue dots – needn't mean you need to upgrade your monitor. Visit the website JScreenFix (**www.snipca.com/43176**) and click the Launch JScreenFix button to run its free pixel fixer. Drag the square containing what looks like TV distortion over a stuck pixel and leave the tool running for at least 10 minutes. It uses HTML5 and JavaScript to try and unstick your frozen pixel so that it works again. You may need to run the tool a few times. JScreenFix may also solve problems with 'image persistence' – when graphics linger on your screen after you've closed the related program.

Another option is to press the stuck pixel with a soft cloth, but don't apply too much pressure or you could damage your screen. Dead pixels, which are black, can't usually be fixed. ■

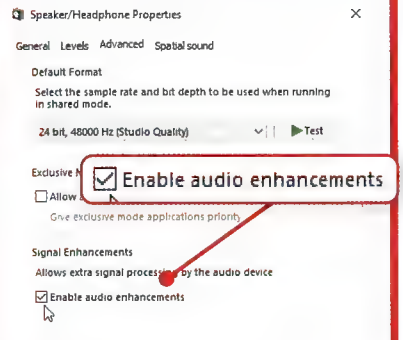
ENHANCE YOUR SOUND QUALITY

If the audio that comes through your PC's speakers or headphones is weak or distorted, there are several tricks to try before upgrading your sound card.

First, open 'Audio inputs and outputs' in Device Manager, right-click Speaker/Headphones and choose 'Update driver'. Click 'Search automatically for drivers' to find and install the latest drivers, then repeat this for your other audio devices.If no new drivers are available, right-click the speaker icon in your system tray and choose 'Troubleshoot sound problems'. Select the audio device that's causing you trouble and Windows will (hopefully) suggest how to fix it.

One option is to apply audio enhancements. In Windows 10, right-click the speaker icon and choose Sounds then click the Playback tab. Select 'Speaker/Headphones', click Properties and choose Advanced. Tick the 'Enable audio enhancements' option (see screenshot below) and, on the Enhancements tab, tick the boxes for Bass Boost, Loudness Equalisation and other available options.

In Windows 11, right-click the speaker icon and choose 'Sound settings', then select 'All sound devices' under Advanced. Click 'Speakers/Headphones' and switch on 'Enhance audio'. This will remove – or at least reduce – distortion, boost the bass and apply other tricks to produce superior sound quality.


Speaker/Headphone Properties
General Levels Advanced Spatial sound
Default Format
Select the sample rate and bit depth to be used when running in shared mode.
24 bit, 48000 Hz (Studio Quality)
Test
Enable audio enhancements
Signal Enhancements
Enable audio enhancements

PC BUILDER

System News

Mark Williams looks on as Nvidia continues to wrangle its product line-up.

Mark Williams
Mark is an IT professional with a strong interest in voiding warranties.

The launch of the RTX 4090 went as well as Nvidia could've hoped for. Independent benchmarks confirmed its insane performance at 4K, on average offering 45 percent more performance over the outgoing champion the RTX 3090 Ti, and 65 percent faster than AMD's current top dog the RX 6950 XT.

It isn't without its issues though. Several buyers have reported that the new 12VHPWR adapter can melt the power connector. This is mere weeks after PCI-SIG, the foundation that oversees the specification for the new PCIE 5.0 power connector warned that "some implementations of the 12VHPWR connectors and assemblies have demonstrated thermal variance, which could result in safety issues under certain conditions". It was revealed that the primary cause was tight bends being made near the connector causing some pins internally to disconnect, forcing more current through the other wires causing them to overheat and ultimately start melting the connector.

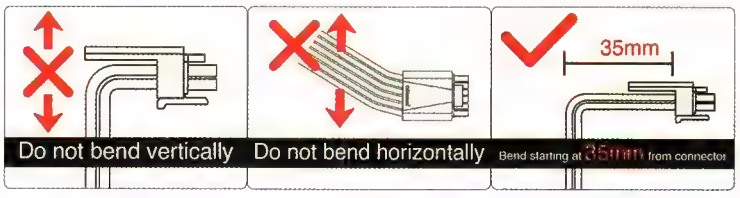
> "Independent benchmarks confirmed its insane performance at 4K, on average offering 45 percent more performance over the outgoing champion the RTX 3090 Ti."

AMD representatives have since stated it will not be using the new connector on its upcoming RX 7000 series. It would seem PCI-SIG and Nvidia need to work on a new revision to the spec to help mitigate this issue.

© reggie_gakil

With the top spot secured, Nvidia continues to struggle with the rest of its line-up. Having announced the "unlaunching" of the RTX 4080 12GB model, which appears would've been stepping on the toes of the RTX 3090 series prices while potentially offering the same or less performance, it's now completely off the table according to some sources. With word that any future RTX 4070 would be an even further cut-down chip than what the 4080 12GB was (and thus even cheaper). It appears Nvidia is struggling to find space in its line-up to differentiate the new 4000 from the outgoing 3000 series cards.

With a new RTX 3060 8GB card having just been silently launched with a 33 percent smaller 128-bit memory bus and rumours of 3080's being cut down into 3070 Ti's, it seems Nvidia is doing everything it can to push sales of old 3000 series GPUs before it has room to introduce new 4000 series parts. The shadow of Ampere will loom over Ada Lovelace's launch for several more months yet. ■



© Cablemod

SHOP TALK

How are RTX 4090 sales going for you since the launch? Is there lots of stock of the high-end 3000 series?

Jaimie, Leader Computers:
"We have seen a very strong uptake of the RTX 4090, even though initial supply was much better than previous launches we are still selling out quickly as stock lands. The huge performance gains over the RTX 3000 series have ensured enthusiasts cough up the big bikkies to stay at the cutting edge!

We have seen strong sell-through of the RTX 3000 series cards across the range without any issues, so I don't expect a huge problem of ageing cards sitting on shelves. With their current pricing the way it is there is plenty of demand for an RTX 3070 or similar!

We are actually pretty comfortable for 3080 and 3090 stock, there's not excessive stock on hand but still some are available, as there was vigorous vendor support to clear the majority of these early in anticipation of the RTX 4000 series launch. I think Nvidia learned from the disastrous launch with the RTX 3000 series and handled the transition considerably better this time!"

Market Watch

A sampling of PC systems available this month

TI COMPUTERS POWER RYZEN 3600

$1,460 | tinyurl.com/APC514TI

This entry-level gaming system appears to be keeping costs down, particularly with the use of the now three-generation old Ryzen 5 3600 CPU and the new but somewhat controversial entry-level AMD GPU in the Radeon 6500 XT.

The use of a pricier B550 motherboard is valid here as the GPU has just four PCIe lanes to play with and running them at 4.0 speeds is quite important to its performance, something B450 cannot do.

While the system as a whole is quite solid and well-balanced for entry-level gaming, it's a little overpriced.

It can't be recommended at its current asking price but if it falls by a couple of hundred dollars, it'll be worth consideration.

CPU: AMD Ryzen 5 3600; **Cooler:** OEM; **Motherboard:** Asus B550-based; **Graphics:** MSI RX 6500 XT 4GB; **Memory:** 16GB Kingston 3200MHz DDR4; **Storage:** 1TB Kingston NVMe M.2 SSD; **Power Supply:** Cooler Master 550W; **Case:** DeepCool Matrixx 40.

MWAVE RESPAWN NINJA MIGHTY - RADEON RX 6600 EDITION

$1,499 | tinyurl.com/APC514MW

Coming in just $40 dearer than the TI Computers system, for gaming, this system is clearly a better choice.

Don't be distracted by the Intel Core i3 CPU, thanks to its quad performance only cores found in higher tier Intel processors it actually performs like a Ryzen 5 5600X in games, offering impressive gaming value. Paired with that is a much more powerful RX 6600 GPU which is currently unbeatable for 1080p performance per dollar, it makes this system a great option for those starting out in PC gaming or who are on a tighter budget. The 1TB SSD and 3rd party CPU cooler is just icing on the cake at that point.

CPU: Intel Core i3 12100F; **Cooler:** BeQuiet Pure Rock Slim 2; **Motherboard:** Asus Prime B660M-A; **Graphics:** Asus Radeon RX 6600 Dual 8GB; **Memory:** Kingston Fury Beast 16GB DDR4 3200MHz; **Storage:** Crucial P2 1TB NVME SSD **Power Supply:** Thermaltake Smart BX 650W; **Case:** DeepCool Macube 110.

THERMALTAKE GENESIS PRO V2

$1,899 | tinyurl.com/APC514TT

It's often difficult to look at systems offered by OEMs. So often they provide poor value for money, and this is no exception. To be blunt, the CPU is three generations old, and the graphics card is just as old, all plugged into an A520 motherboard which is the lowest-tier motherboard chipset for AMD, limiting your IO options and upgrade paths.

The RAM, PSU and mass storage are adequate, in fact, everything except the most important three (CPU/GPU/motherboard) are solid but those three main components at this price level, today, simply aren't worth a second look. Look elsewhere for a better deal.

CPU: AMD Ryzen 5 3600; **Cooler:** Thermaltake TH120 ARGB AIO; **Motherboard:** Asus TUF Gaming A520M-PLUS WIFI; **Graphics:** Asus GeForce GTX 1660 Super TUF Gaming 6GB; **Memory:** Thermaltake ToughRam Z-One RGB 16GB DDR4 3200MHz; **Storage:** 500GB M.2 NVMe, 1TB HDD; **Power Supply:** Thermaltake TR2 650W; **Case:** Thermaltake V150 TG ARGB.

SCORPTEC NITRO RTX 3060

$1,849 | tinyurl.com/APC514SC

Since Alder Lake, Intel has recaptured the budget gaming CPU crown. The 12400(F) and 12100(F) processors are unmatched in their price by AMD. So, seeing one here is a great start.

The motherboard isn't anything fancy but it's a solid choice here, and plugged into it is the RTX 3060 which offers around 30 percent more performance relative to the similarly priced Thermaltake system. A decisive win here.

With otherwise solid components for the rest of the system this rig is a much easier recommendation at this price tier, especially with a drop in upgrade path to Intel's 13th gen CPU available, this system should last many years to come. Just keep an eye on your SSD drive space with large/multiple game installs.

CPU: Intel Core i5 12400F; **Cooler:** OEM; **Motherboard:** Asus Prime B660M-A WIFI; **Graphics:** Asus Dual GeForce RTX 3060 OC 12GB; **Memory:** Corsair Vengeance LPX White 16GB 3200MHz DDR4; **Storage:** Western Digital SN570 500GB M.2 SSD, Seagate BarraCuda 2TB HDD; **Power Supply:** SilverStone Decathlon 650W; **Case:** Thermaltake S100 White mATX.

PC BUILDER

Blueprints

Value- and performance-driven hypothetical builds

BUDGET

A perfect balance between price and peformance.

At the time of writing, a whole new range of chips and GPUs are available. Exciting times, then, for our new Blueprint machines? Well, yes and no. For the mid-range and turbo machines, yes, but unfortunately we don't get to add these new toys into our budget machines just yet. For now, our budget CPUs and GPUs don't alter.

For team Intel, that means that the trusty Core i5-12600K is once again at the wheel, although it does partner up with a new GPU. Yes, we know we just said nothing had changed, but hold on, it's nothing to get too excited about. Fluctuations in pricing mean that we swap out our previous MSI graphics card for a similarly specced Zotac one. This GPU is an RTX 3060 OC like the MSI and has 12GB of GDDR6 to play with. It's nothing revolutionary but is still a great buy.

Aside from that, the PSU is swapped out for an Asus ROG Strix unit that has the same wattage but a higher efficiency rating. Now we get to see an 80+ Gold PSU instead of an 80+ Bronze one – and all for the same price too.

Over on team AMD's budget rig, there aren't too many drastic changes this time either. The driver behind the wheel here also remains the same but, unlike the Intel machine, we keep the existing GPU.

Where we have swapped out parts is in our storage and power supply. Corsair's trusty MP600 PCIe 4.0 SSD comes in to take the role as our main storage solution while Seagate's SkyHawk Surveillance remains in place as our backup HDD with a large 4TB capacity. Another similarity to the Intel machine is that we've also replaced an 80+ Bronze-rated PSU for an 80+ Gold-rated unit with a Cooler Master MWE Gold 550W unit. Prices on all other components have remained fairly stable with no major fluctuations, which is a good thing for those on a budget.

"A whole new range of chips and GPUs are available. Exciting times, then, for our new Blueprint machines? Well, yes and no."

AMD INGREDIENTS

Part		Price
Case	Corsair 4000D Airflow	$120
PSU	550W Cooler Master MWE Gold 80+ Gold NEW	$120
Mobo	MSI B550M PRO-VDH WiFi AM4	$149
CPU	AMD Ryzen 5 5600X	$299
GPU	MSI Radeon RX 6650 XT MECH 2X OC 8GB	$649
RAM	16GB (2 x 8GB) PNY XLR8 Gaming EPIC-X RGB @ 3600MHz	$95
SSD	500GB Corsair MP600 PCIe 4.0 M.2 NEW	$160
HDD	4TB Seagate SkyHawk Surveillance 7200	$129
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$60
Total		$1,781

INTEL INGREDIENTS

Part		Price
Case	Corsair 4000D Airflow	$120
PSU	550W Asus ROG Strix 80+ Gold NEW	$140
Mobo	Asrock B660 Pro RS LGA 1700	$179
CPU	Intel Core i5-12600	$359
GPU	Zotac GeForce RTX 3060 Gaming Twin Edge OC 12GB NEW	$580
RAM	16GB (2 x 8GB) PNY XLR8 Gaming Epic-X RGB @ 3600MHz	$95
SSD	500GB MSI Spatium M450 PCIe 4.0 M.2 SSD	$89
HDD	4TB Seagate SkyHawk Surveillance 7200	$129
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$60
Total		$1,751

"We've stretched our wallets slightly to bring these fresh processors in, but for their benefits, it's worth it."

MID-RANGE

A game-ready machine that can also handle demanding work.

For the budget range we didn't see anything too exciting, but here, we can start to introduce some of the latest components to futureproof our mid-range machines. That's right, AMD's Raphael CPUs and Intel's Raptor Lake chips have joined the party and we welcome them both with open arms. It means we've stretched our wallets slightly to bring these fresh processors in, but for their benefits, it's worth it. For our AMD build, welcome the 6-core Ryzen 5 7600X. At $515, it has 12 threads, a maximum boost frequency of 5.3GHz, and features an AM5 socket.

By changing this CPU, we have to upgrade to an AM5 motherboard and, as our mid-range budget isn't quite as forgiving as our Turbo builds, we've opted for one of the cheapest compatible ones on the market, the Asus Prime B650M-A AX Micro ATX. There's nothing special going on here, but it's still a respectable board to house our new chip. This has also resulted in an upgrade to DDR5 RAM with Corsair's 32GB Vengeance kit.

For the Intel machine, we didn't need to change the motherboard as the new 13th gen Raptor Lake chips run on the same LGA-1700 socket as the previous Alder Lake processors. However, we changed it to the MSI Pro Z690-A for its DDR5 support and brought in the same Corsair RAM we used for the AMD build. As for the CPU, this is the new Intel Core i5-13600K. Containing 14 hybrid cores (six performance and eight efficient), this latest i5 chip has four more cores than last year's 12600K and a four percent turbo boost frequency, to 5.4 GHz.

One final change on the midrange Intel build is the GPU. Gigabyte's Gaming OC 3070 Ti card slips under the $1,000 mark and in it goes. This is a welcome addition to the build but, that aside, the rest of the components stay the same as before.

AMD INGREDIENTS

Part		Price
Case	Nzxt H7 Flow	$210
PSU	750W Nzxt C750 80+ Gold	$180
Mobo	Asus Prime B650M-A AX Micro ATX AM5 NEW	$399
CPU	AMD Ryzen 5 7600X NEW	$515
Cooler	Cooler Master Masterliquid ML240L RGB V2	$95
GPU	Asrock Radeon RX 6800 XT Phantom Gaming D OC 16GB	$929
RAM	32GB (2 x 16GB) Corsair Vengeance DDR5 CL40 @ 5200MHz NEW	$269
SSD	1TB Crucial P5 Plus NVME M.2 PCIe 4.0	$179
HDD	4TB Seagate SkyHawk Surveillance 7200	$129
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$60
Total		$2,965

INTEL INGREDIENTS

Part		Price
Case	Nzxt H7 Flow NEW	$209
PSU	750W EVGA SuperNova 750 GA 80+ Gold	$149
Mobo	Asrock Z690 Pro RS LGA 1700	$299
CPU	Intel Core i7-12700F	$519
Cooler	Cooler Master MasterLiquid ML240L RGB V2	$95
GPU	MSI Ventus 2X OC GeForce RTX 3070 8GB	$999
RAM	32GB (2 x 16GB) Corsair Vengeance RGB RT CL16 @ 3600MHz	$279
SSD	500GB Corsair MP600 Pro LPX M.2 PCIe 4.0	$129
HDD	4TB Seagate Barracuda	$120
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$60
Total		$3,145

"Kicking things off on team Intel, we replaced our i9-12900K with the Intel Core i9-13900K. This monster of a processor again features a hybrid architecture with a total of 24 cores (eight performance and 16 efficient), which is eight more than the previous 12900K."

TURBO

The maximum PC.

Unfortunately, the latest GPUs arrived just too late to sneak into our builds. We prioritised our review of the RTX 4090 this issue, but expect that card to appear in our builds and Blueprints next issue. Kicking things off on team Intel, we replaced our i9-12900K with the Intel Core i9-13900K. This monster of a processor again features a hybrid architecture with a total of 24 cores (eight performance and 16 efficient), which is eight more than the previous 12900K.

We included the same RAM sticks from the mid-range machines but opted for the 64GB variant. We didn't need to swap our motherboard out to accommodate the new chip.

Though we included the top new CPU from Intel in that build, we won't be using the top AMD Ryzen 9 7950X. Instead, we have the next best thing, the AMD Ryzen 9 7900X. It's still an awesome piece of hardware, is $220 cheaper than the Ryzen 9 7950X, and outperforms the previous chip in this build, the Ryzen 9 5950X while costing around the same. However, this means a new AM5 motherboard has to be brought into the equation. We've gone with a great performing one too, featuring the fastest chipset available, the AMD X670 Extreme. This gives us great futureproofing, with the most compatibility and overclocking potential. The CPU alteration also means we need a new cooler, the Cooler Master MasterLiquid ML360R RGB AIO, which should keep our system running smoothly for the same price. We kept the same Asrock OC Formula Radeon RX 6950 XT GPU in the build as it's still an outstanding graphics card.

The DDR5 Corsair Vengeance is a great pick-up for the price to go in the AMD build. Finally, there was one other change to both machines, and that was the PSU. Both now see the 1000W EVGA SuperNova 1000 GT 80+ Gold for some healthy futureproofing.

AMD INGREDIENTS

Part		Price
Case	Phanteks Enthoo Pro 2 Tempered Glass	$220
PSU	1000W EVGA SuperNova 1000 GT 80+ Gold NEW	$280
Mobo	Asrock X670E PG Lightning ATX AM5 NEW	$539
CPU	AMD Ryzen 9 7900X NEW	$949
Cooler	Cooler Master MasterLiquid ML360R RGB 66.7 CFM 360mm NEW	$249
GPU	Asrock OC Formula Radeon RX 6950 XT 16GB	1,899
RAM	64GB (2 x 32GB) Corsair Vengeance DDR5 CL40 @5200MHz NEW	$599
SSD	1TB WD Black SN850X M.2 PCIe 4.0	$249
HDD	6TB WD Blue 5400 HDD	$189
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$60
Total		$5,233

INTEL INGREDIENTS

Part		Price
Case	Phanteks Enthoo Pro 2 Tempered Glass	$220
PSU	1000W EVGA SuperNova 1000 GT 80+ Gold NEW	$280
Mobo	Asus TUF Gaming Z690-Plus WIFI DDR5 LGA 1700	$389
CPU	Intel Core i9-13900K NEW	$1,099
Cooler	Nzxt Kraken X73 73.11 CFM 360mm	$239
GPU	Gigabyte GeForce RTX 3090 Ti Gaming Gaming OC 24GB	$2,199
RAM	64GB (2 x 32GB) Corsair Vengeance DDR5 CL40 @5200MHz NEW	$599
SSD	1TB WD Black SN850X M.2 PCIe 4.0	$249
HDD	6TB WD Blue 5400 HDD	$189
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$60
Total		$5,523

The best as voted by Australians

Congratulations to the award-winning tech brands that took out honours in the 13th annual Mozo People's Choice Awards

TELEVISIONS
TCL, JVC, Hisense, Sony, Samsung

HEADPHONES
Bose, Apple, Jabra, Sennheiser, Anko, Sony, Samsung

SMARTPHONES
Apple, Google Pixel Oppo

mozo.com.au

mozo
The money saving zone

QUICK TIPS

The problem solvers

The APC team field problems across the spectrum of devices and software. Learn a new trick or fix you can use.

Synology mesh setup

I'm a long-time user of a Synology RT2600ac router, and my biggest frustration has always been extending my Wi-Fi network to cover the whole house. I've experimented with extenders and a Powerline network with Wi-Fi, but having to prompt my devices to move from one network to another feels like a compromise.

Mesh networks would fix this problem, so you can imagine how excited I was to discover my RT2600ac could combine with other Synology routers to deliver such a solution. What do I need for such a setup? And how do I go about configuring a Synology mesh network?

Kevin Tuma

APC responds: You can create a simple two-device mesh network by combining your RT2600ac with either Synology's new flagship Wi-Fi router RT6600ax, or its budget WiFi 5 router (MR2200ac. This should be sufficient to boost the signal to one dead spot in your home. You can then add extra MR2200ac routers as additional satellites should the need arise.

If you chose the more expensive RT6600ax model, that would be the centerpiece of your new mesh network, and you'd need to reconfigure your RT2600ac as a satellite. However, by choosing the MR2200ac model to suit your budget, that becomes the satellite to your RT2600ac, which would remain as your primary router.

The key requirement for deploying the older RT2600ac and MR2200ac routers in a mesh environment is that they're both running the same version of SRM – 1.2.5 or the latest version of Synology's firmware (SRM 1.3.1). Were you to pair either router with the RT6600ax, you'd need to upgrade them to SRM 1.3.1. There are other good reasons for upgrading to SRM 1.3.1 too, not least its support for VLANs, allowing you to segment network devices into separate, isolated networks for security reasons.

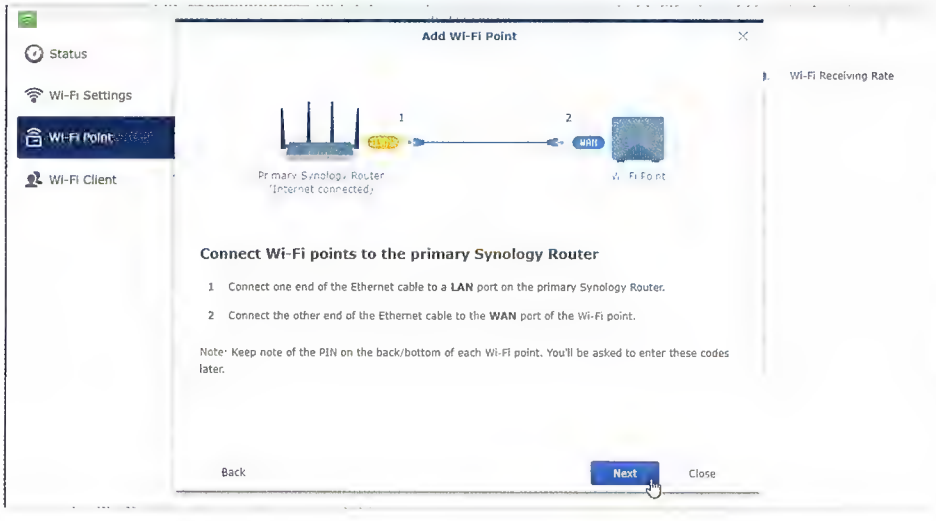
At the time of writing, SRM 1.3.1 is rolling out to both models in a staggered fashion, so if you've not yet received an alert that SRM 1.3.1 is available, navigate to Control Panel > System > Update & Restore to see if the automatic check finds it. If not, you can download the update manually from Synology (**www.synology.com/enau/support/download**), then apply it via the 'Manual SRM Update' button. The update takes around 10 minutes.

After purchasing your MR2200ac, you'll need to initialize it as a regular router alongside your RT2600ac. Log into the web interface and upgrade it to SRM 1.3.1, then restore it to factory settings via the same Update & Restore tab.

Once done, connect an Ethernet cable from one of your RT2600ac's LAN ports to the WAN port of your MR2200ac. Now, from your RT2600ac's web interface, open Wi-Fi Connect and select Wi-Fi Point. Click Add, select 'Connect with both wired and wireless Wi-Fi points' and follow the wizard. Make a note of the tips for deploying your mesh points after they have been set up, and power on the MR2200ac when prompted.

When the LED flashes blue, it's ready, so click 'Wi-Fi Ports Ready' and wait for it to detect the MR2200ac. You'll need to enter the latter's PIN code (on the back of the machine), then wait while your RT2600ac completes the configuration. The MR2200ac becomes a 'dumb' Wi-Fi access point that allows you to seamlessly extend your network without having to set up new network IDs or passwords. You'll be able to view its status from your RT2600ac's web interface under Wi-Fi Point.

You can now disconnect the MR2200ac from your main router's LAN port and experiment with placing it around your home for best effect. Wi-Fi Point will keep you updated as to the signal strength and recommend you move it, if necessary.


Status
Wi-Fi Settings
Wi-Fi Point
Wi-Fi Client
Add Wi-Fi Point
Wi-Fi Receiving Rate
1
2
WAN
Primary Synology Router
(Internet connected)
Connect Wi-Fi points to the primary Synology Router
1 Connect one end of the Ethernet cable to a LAN port on the primary Synology Router.
2 Connect the other end of the Ethernet cable to the WAN port of the Wi-Fi point.
Note: Keep note of the PIN on the back/bottom of each Wi-Fi point. You'll be asked to enter these codes later.
Back
Next
Close

All of Synology's current router lineup support mesh.

Visible Ubuntu shares

Is there a way of making my Ubuntu shared folders visible when browsing in Windows? I can address the share directly by typing \\SHARENAME into the Address bar of File Explorer, but it's frustrating I can't simply see the drive when I click the Network icon.

Leonard Marquez

APC responds: Ubuntu's implementation of Samba relies on SMB 1.0/CIFS file sharing support in order to make its folders visible in Windows' Network view. SMB1 support was dropped by default in Windows 10 from version 1511 onwards. While you can switch the feature back on, it isn't recommended for

© Samsung

security reasons.

You'd have thought Samba would have addressed this issue by now – indeed, an unimplemented patch dating back to 2015 can be found in the Samba bug tracker that would resolve the problem. But with no official fix forthcoming, Steffen Christgau has taken matters into his own hands and developed a workaround – wsdd (Web Service Discovery host daemon). This Python-based tool has finally been added to the official universe package repository for Ubuntu 22.04 and Linux Mint 21. If you're running either, install it with the following command:

sudo apt install wsdd

A dedicated repo exists for older versions of Ubuntu, Mint, and Debian, instructions for adding this can be found at the wsdd GitHub page (**https://github.com/christgau/wsdd**) where you'll find help for other OSes too, including macOS. Once installed, open Network in File Explorer on any Windows PC and your Samba shares should now be visible.

Mini Zen 4

Is it possible to upgrade a mini-ITX system with a 1U power supply to a Zen 4 system with Windows 11? I know it's a new system, but is there a possibility? Again, this would be a low-power upgrade with no video card.

Daniel Serrano

APC responds: In theory, yes. Asus has already announced both micro-ATX and mini-ATX boards for AMD's Zen 4 Ryzen 7000 series – in your case, the Mini-ITX ROG Strix X670E-I Gaming WiFi will meet your setup's needs. All four Ryzen 7000 chips also come with integrated graphics (RDNA2 GPUs) to avoid the need to add a separate graphics card.

In terms of power draw, the two lower-end models, the Ryzen 7 7700X and Ryzen 5 7600X, draw a similar amount of power (105W TDP) to the previous-generation Ryzen 5000X series – significantly more than low-power systems but still less than the top-of-the-line models, the Ryzen 9 7950X and 7900X, which draw 170W TDP with a peak 230W. With this in mind, make sure your 1U PSU supplies a minimum of 500W (600W should offer a comfortable minimum with some overhead).

Aside from power draw, your main consideration will be space inside your existing case for such elements as cooling. Again, there's good news: CoolServer's new Zen 4 cooler product lines include low-profile models specifically targeting 1U servers, so even if you're using a non-1U case, they're still options. Two passive coolers potentially fit the bill: the AM5 1U1CA can dissipate up to 150W, while the SP5 1U-S11 radiator claims up to 260W.

Asus has announced a Zen 4 mini-ITX board.

To sum up, there is mini-ITX support for the new Zen 4 series – you'll need to upgrade the mobo, CPU, cooling, and RAM for an entry-level system based around the Ryzen 5 7600X.

With that kind of investment, it pays to double-check all specs and measurements to ensure everything fits inside your existing case before you take the plunge. That said, if the case ends up being the stumbling block, you could always upgrade that too.

Drive failure query

I'm the owner of a Lenovo Legion 5i Pro laptop (2022 model). I swapped out the supplied Samsung Gen 4 1TB drive for a Samsung 2TB 980 Pro with a heatsink, as I wanted extra storage.

Unfortunately, after two months, the drive failed with no warning. I paid for Lenovo Premium Care to fit a replacement drive, then claimed for the damaged drive from Samsung direct. Although my data was backed up, I had to create a Lenovo boot drive to reinstall Windows from scratch. Any advice on how I can prevent this from happening again?

Gregory J Kimbrell

APC responds: We feel your pain. Going forward, you should be able to protect yourself from such pain with a few tweaks and a working backup regimen.

A quick glance at the hardware manual for the Legion 5i reveals its NVMe SSD slots are reasonably accessible, and that in this case there are two, allowing you to fit two drives simultaneously.

Assuming your laptop has two slots, we would strongly recommend pressing your old Gen 4 1TB drive back into action alongside the replacement 2TB 980 Pro. This serves two purposes: the first is that it allows you to separate your data from your OS, so if the Windows drive fails, you won't need to restore your data backups.

The second is that the additional drive gives you the option of using it as a backup for your main drive – in this case, a regularly updated drive image taken using a tool like Macrium Reflect Free (**www.macrium.com/reflectfree**). Set up a backup regimen that mixes monthly full backups with weekly or daily differential backups and set limits to the number of backups to prevent them from taking up all your drive space.

In an ideal world, you'd use the existing 1TB drive as your boot drive, and the 2TB drive as your data/backup drive. Consider using Macrium to transfer the contents of your 2TB drive to the 1TB drive (space permitting), then enter the UEFI to make your 1TB drive the boot default. Once you've successfully booted from it, wipe the former then move your data from the old 1TB drive to the freshly formatted new one. Doing so alleviates any storage space issues you previously had with the 1TB drive.

In addition, APC recommends installing Samsung's Drive Magician (**https://semiconductor.samsung.com/consumer-storage/magician/**) to monitor the replacement Samsung drive. This should provide you with a tool to not just keep an eye on the drive, but also provide some form of early warning system. Finally, make sure you create the Macrium rescue media on a blank flash drive (512MB or larger will suffice). If the worst happens, you can be up and running in under an hour after fitting the replacement drive yourself – no more Lenovo engineer callouts required. ■

© Tor

WINDOWS

Manage hardware with Windows 11

It's time to get under the hood and make sure your hardware is set up properly, with Nick Peers.

YOU'LL NEED
HWiNFO
(www.hwinfo.com)

Wi-Fi Analyzer
(https://matthafner.com/wifi-analyzer)

Keeping tabs on the various components and peripherals that make up your PC's hardware can be a time-consuming task, but Windows 11 has you covered. The operating system has long offered a myriad of tools for managing and tweaking your hardware but has traditionally struggled to make them easily accessible and sensibly organised.

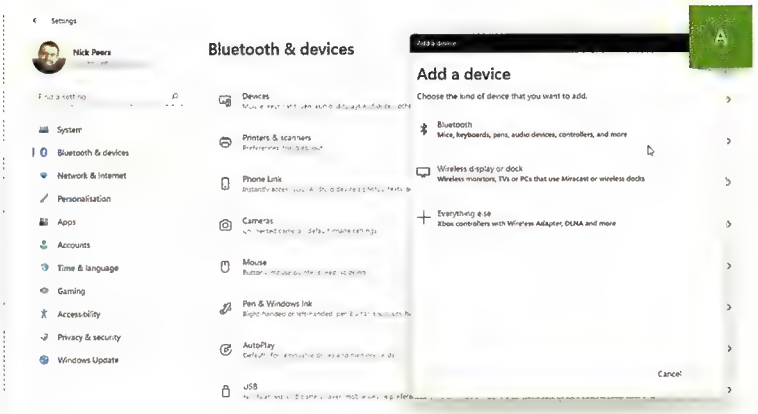
Microsoft has pulled more options into the Settings app, so most of what you need is under a single section (Bluetooth & Devices), with shortcuts to other key areas (such as your display and network settings) clearly labeled. It's not all good news – some key settings remain in their previous locations, but Microsoft has removed easy shortcuts. In this tutorial, we'll take you on a tour of the Windows 11 Settings app, revealing how to access those hidden tools, and where to turn when you need functionality and help not offered in Windows 11 itself.

xplore Windows Settings

There are three main areas to explore when tweaking hardware using Windows 11's Settings tool: System, Bluetooth & Devices, and Network & Internet.

Bluetooth & Devices covers all wireless and wired external devices except your display. There are eight sections – the annotation provides a quick summary of what to expect from some of the more self-explanatory ones. At the top, you'll find Devices, complete with an 'Add device' button.

Click this to pair Bluetooth devices or other wireless tech to your PC, such as Miracast-streaming TVs and displays **[Image A]**. To set up an Android phone, use the 'Open Phone Link' button instead.



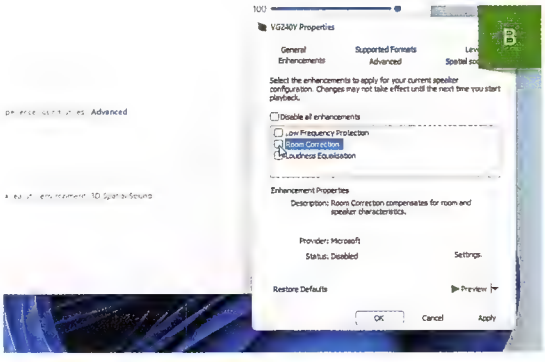
Click Devices to get a broad overview of your PC's key components and peripherals. Individual devices can be removed here, but there's little else of interest until you scroll down to discover shortcuts to Sound, Display, and somewhat surprisingly, the classic Devices and Printers Control Panel (see step five).

Configure audio devices

One welcome improvement in Windows 11 is the incorporation of the old Sound Control Panel and related tools such as Volume Mixer into the main Settings tool. It can be accessed directly via System > Sound. Here you'll find options to configure both output (speakers and headphones) and input (microphones) devices.

Thanks to the breadcrumbs navigation system at the top of the Settings window, it's a lot harder to get lost than with previous versions of Windows. Select a device to tweak its properties, from simple volume control to enabling advanced features.

There are still rare occasions when clicking an option (such as Advanced under 'Enhance audio') will bring up the device's own Properties screen **[Image B]**. For the most part, though, you can now access virtually everything you need to set up, configure and troubleshoot your speakers, headphones, and microphone from one location. And if all else fails, or you're a stickler for old-school dialogs, click 'More sound settings' from the main screen to access the classic Sound Control Panel.

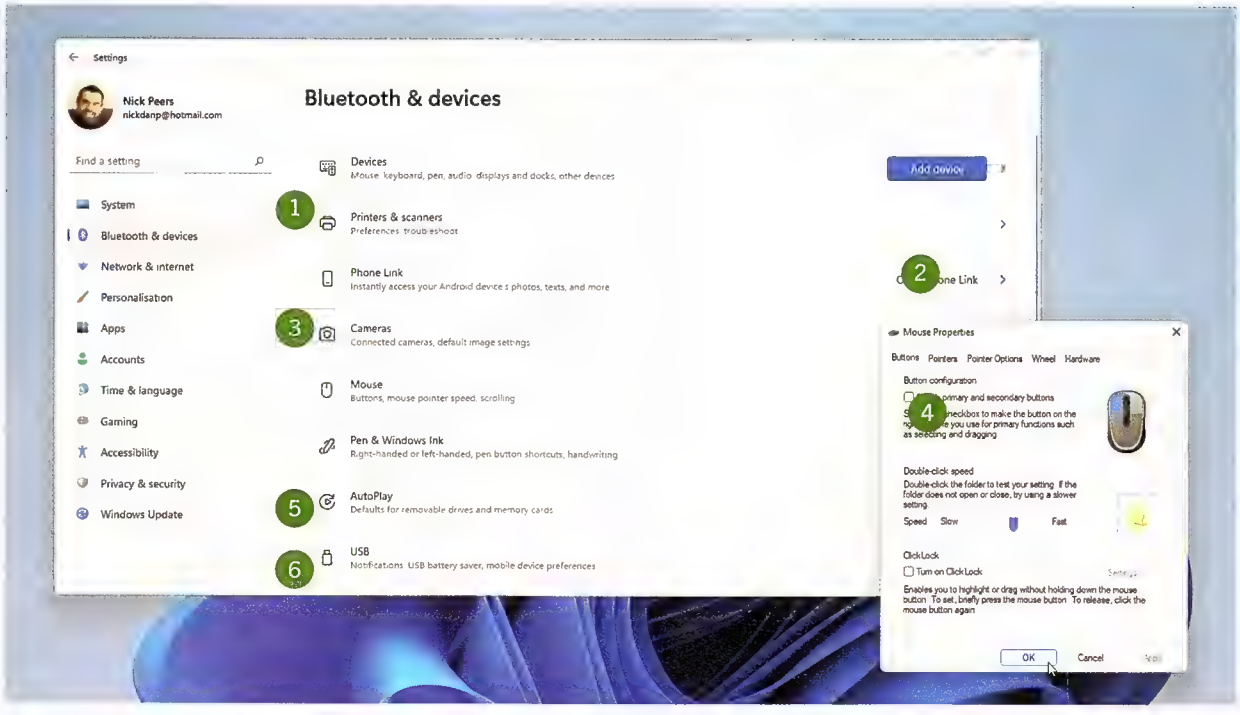


Tweak display settings

Visit System > Display under Settings and you'll find a set of controls for configuring your graphics adapter and monitor. This covers the fundamentals, such as desktop resolution and refresh rate, plus handy brightness and color tools. Use 'Night light' to reduce eyestrain at night, and here you'll find settings like HDR for supported games, apps, and crucially, displays.

Attach a second monitor and a new Multiple displays section appears at the top of the Displays tool. Use the 'Show only on...' dropdown to extend or duplicate the display, then use the Identify button to locate each display if necessary. From here, click and drag one of the displays to reconfigure its layout. For most people that simply involves making sure the displays align to their physical layout on your desk, but you can also place displays on top of each other for more complex setups.

Scroll down to the Advanced display section to change the display's refresh rate or select Graphics to configure graphics settings on an app-by-app basis. In most cases, Windows makes the



TOUR BLUETOOTH & DEVICES

1. PRINTERS & SCANNERS

Click here to not just view installed printers (and install new ones), but access various printer options and change Windows' default setting of choosing your default printer for you.

2. PHONE LINK

Use this to connect your Android phone to your PC so you can instantly access media, send and receive texts, and more. You'll be redirected to the Store to download an app on first use.

3. CAMERAS

View connected cameras (including video cameras) and add new network ones. You can tweak your camera's video and audio from here and, from Windows 11 22H2, apply cinematic effects.

4. MOUSE

Core mouse features are now housed here, such as the primary mouse button and pointer speed. Click 'Additional mouse settings' to access more options via the traditional Mouse Control Panel.

5. AUTOPLAY

Configure what happens when you insert USB drives or memory cards into your PC. By default, AutoPlay is disabled for security reasons, but you can choose specific apps or actions.

6. USB

This section is limited to two on/off options: receive warnings if you run into problems when plugging in a USB device, plus get notified if your PC is charging slowly over USB.

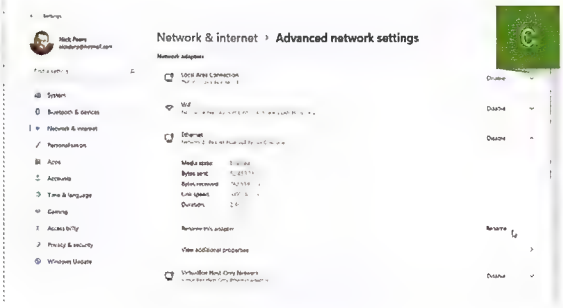
correct choice between high performance and power saving, but you can make changes here. Click 'Change default graphics settings' for further options, such as hardware-accelerated GPU scheduling, to enable or disable.

While the basics are covered in Settings, if you want to dig deeper into your graphics settings, make sure you've installed your manufacturer's drivers. AMD and Nvidia both provide their own configuration tools, which let you dig even deeper.

Get more accurate colours

One piece of hardware that's often overlooked when it comes to your PC is your monitor. You plug it in, the picture magically appears, and then once you've set the display resolution, that's pretty much it. However, you may be missing several tricks.

Although Windows usually correctly lists your monitor's model when you select 'Advanced display', that doesn't mean you're necessarily running dedicated drivers. In most cases, Windows will simply install a Generic PnP Monitor driver which does just enough to give you access to basic controls like refresh rates.



If your monitor came with an installation CD you can try installing drivers from there or locating them online at the manufacturer's website. In most cases, these drivers are tiny – barely 10KB in some cases – and usually comprise a maximum of three files. The INF and CAT files are the actual driver files, while an ICM file is a set of color profile settings that aim to render colours more accurately through your monitor.

You can attempt to install these drivers through the Update Driver button in Device Manager under the monitor's Driver tab. Select 'Browse my computer for drivers' followed by 'Let me pick from a list of available drivers on my computer'. Click the Have Disk... button and browse to the folder containing your driver files. The

actual driver should be selected and clicking OK should force Windows to accept your manufacturer's driver as well as the colour profile settings.

To verify the ICM file has been correctly installed, navigate to Advanced display and click 'Display adapter properties for Display' to open a separate window. Switch to the Colour Management tab and click the button to open another window. This should list the monitor's own ICC profile; if it doesn't, tick 'Use my settings for this device', click Add and either select the colour profile file from the list or click Browse to manually add it.

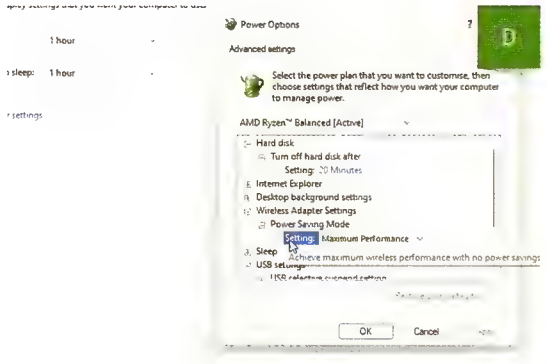
Configure your networks

Visit Network & Internet for an overview of your current network setup. At the top, you'll see your connection type (Ethernet or Wi-Fi), status, and data usage for the past 30 days. You'll also see your network's properties, Public or Private. If you have shared folders, it will be set to Private, but if not, the recommended setting is Public. You can easily connect to other shares, but no one can see your PC in return.

Find out more about your network by clicking either WiFi or Ethernet depending on your connection type. You can edit IP and DNS addresses here, but if you need to dig deeper, navigate back to Network & Internet, scroll down and select Advanced network settings. Expand your network interface where you can monitor various stats, plus rename the adapter **[Image C]**.

Scroll down to view options to reset your adapters to their initial settings, plus a shortcut to 'More network adapter options' if you're nostalgic for the older Control Panel. You'll be deposited at Network Connections where you can troubleshoot individual connections (select one and click 'Diagnose this connection').

Go back to 'Network & Internet' and you'll find a shortcut to the Network and Sharing Centre where you can access 'Media streaming options' (turn your PC into a UPNP device) and 'Change advanced sharing settings', for options such as switching on public folder sharing and disabling password-protected shares.



FIX YOUR WI-FI CONNECTION

While Windows Settings provides some troubleshooting tools to deal with network problems, one area it can't help you with is the performance of your Wi-Fi network. If you aren't getting the expected transfer speeds or are experiencing frequent dropouts, use the free Wi-Fi Analyzer tool (**https://matthafner.com/wifi-analyzer**).

Once installed, the app will display a summary of your current connection, including signal strength. A Networks tab provides a list of networks within range (or just outside range), providing you with an idea of how many networks are in your neighborhood and whether they're causing interference.

To confirm this, switch to the Analyze tab to view a chart that displays networks according to the channel they're transmitting on. If Wi-Fi Analyzer detects you could improve your signal by switching to a different channel, it will highlight it. However, the actual change will require you to log on to your router or access point's configuration utility to manually do so.

All core functionality is in the free version, but a Pro version ($3) is worth trying to see if the additional features, including connecting to networks directly from the app, are worthwhile.

Tap into legacy Windows tools

Despite Microsoft's best efforts, you may still be unable to confine yourself to the Settings tool when it comes to configuring hardware.

Device Manager, which is still easily accessible by right-clicking the Start button, remains a crucial tool, primarily for troubleshooting as we explained in these pages in last month's issue. However, it's not the only throwback from earlier versions of Windows.

Another leftover feature is the Devices & Printers tool, which first made its appearance in Windows 7. This is accessed directly from the Devices section of Bluetooth & Devices. It provides a visual overview of every single external device attached to your PC, including some additional wireless options, such as UPnP media streaming devices.

This is more useful than the Settings tool in that you can right-click each device to access additional options, including direct links to troubleshooters as well as a properties screen. This gives you a summary of the device itself, plus links to all Device Manager entries related to the hardware. That means not just the device, but also any ports it's connected to (such as the underlying USB controller).

Manage power options

If you're a laptop user or looking to troubleshoot power-related problems such as a PC that won't stay asleep, then you'll find the lack of options in Settings (System > Power) disappointing. You are basically limited to setting a time when your display turns off or your PC goes to sleep, plus choosing a power mode (performance, balanced, or power saving).

Despite the lack of options, there's no easy shortcut provided to the old Power Options Control Panel. The quickest way to get to it is to press Win-R, type powercfg.cpl, and hit Enter. This is where you

can set up your own custom power plans or perform minor tweaks to existing settings. To do the latter, click 'Change plan settings' next to the currently selected plan followed by 'Change advanced power settings'.

This opens a separate window where you can specify individual power settings for different parts of your system **[Image D]**. Here, for example, you can set a time to power down your hard drives after a period of inactivity, plus disable or enable USB selective suspend depending on whether your laptop is plugged in or running on battery. This latter option effectively disables USB ports when the device connected to them is idle to prevent battery drain from devices drawing power from the port.

Other options include preventing your PC from going to sleep when playing multimedia content as well as disabling 'wake timers', which basically refer to scheduled actions including backups or virus scans. To learn more about each option, simply hover your mouse over its name in the list.

Troubleshoot sleep and hibernation issues

The solution to many power-related problems usually lies in tweaking Power Options or seeking out a Power Management tab on a device's properties in Device Manager. But how do you identify the culprit if it's not obvious?

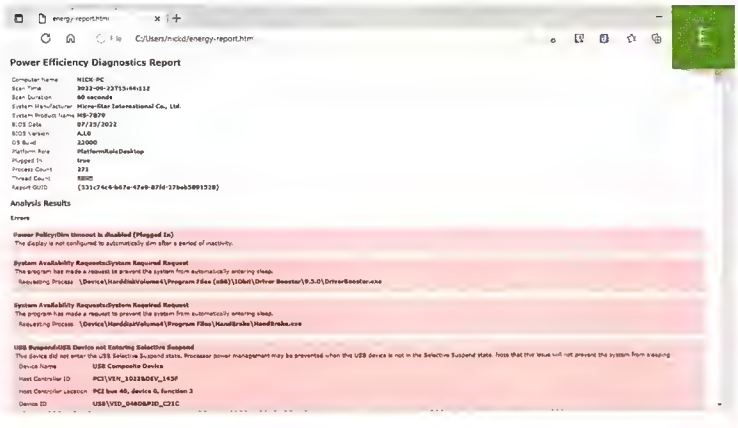
The solution is a command-prompt tool: powercfg. Right-click the Start button and choose Windows Terminal (Admin) to open a command prompt. If your PC refuses to stay asleep, type **powercfg/lastwake** and hit Enter to see what last woke it up, then use this as the basis of your troubleshooting.

To view a list of what drivers and apps can wake your PC, type **powercfg/requests**, then follow it up with **powercfg/waketimers** to view a list of services that can do the same.

If you're still no closer to finding the culprit of your sleep-related woes, generate a detailed report of your energy and power usage by typing the following command:

powercfg/energy

The report takes about 60 seconds to generate and is then saved to the root of your user folder as energy-report.html. Double-click it to view it in your web browser, and you'll see a list of 'errors'. These aren't necessarily problems, but among the recommendations for cutting power usage may be clues as to why your PC won't sleep **[Image E]**.



Keep an eye on your hard drives

Your hard drives are a key part of your system, so it pays to find ways of keeping a close eye on their performance and health.

The simplest solution here is to look for a utility from the drive's own manufacturer, such as Magician for Samsung's SSD and NVMe drives (**https://semiconductor.samsung.com/consumer-storage/magician/**), or Kingston SSD Manager (**www.kingston.com/support/technical/ssdmanager**).

SAMSUNG Magician
Over Provisioning
Allocates a certain capacity of the SSD to an available space to improve the performance and lifetime of the SSD. Note: Data may be damaged if it is a RAW partition
Clear OP
Set OP
13GB

You'll find tools for monitoring SMART status, drive temperature, and scanning your drive for errors along with benchmarking to verify that you're getting the performance you expect.

Here, you'll also find several performance optimisations, including a feature called over-provisioning. Select this and you'll gain extra performance benefits and extend the drive's overall lifespan **[Image F]** – but be aware that this is in return for surrendering up to 10 percent of the drive's capacity.

Also, keep an eye on potential firmware updates for your drives. Again, these tools provide further means for checking (and updating) your drives. ■

GET A DETAILED SUMMARY

One area where Windows still falls short is in providing a detailed summary of your hardware setup. Aside from the listing of processor and RAM under System > Settings > About, you can run the System Information tool for more information, but you won't get much more than you'd find manually trawling through Device Manager.

If you'd like a proper look at your system, we recommend the free version of HWiNFO (**www.hwinfo.com**). This provides you with two windows: a System Summary provides detailed information about your motherboard, CPU, and GPU while the main screen bears a superficial resemblance to the Components section of System Information but shows much more. Highlights include being able to trace each individual USB device to its parent USB controller and get more detailed information on hardware components and their capabilities.

Click Sensors to monitor in real-time key aspects of your hardware, from voltage and temperatures to the hard drive's SMART status and memory usage. HWiNFO could prove to be an essential part of your hardware toolkit.

WINDOWS

Organise your media server

Bring some order to your sprawling media collection, with Nick Peers.

YOU'LL NEED
Two tools feature in this tutorial
Rename My TV Series 2
free
(www.tweaking4all.com/home-theatre/rename-my-tv-series-v2/)

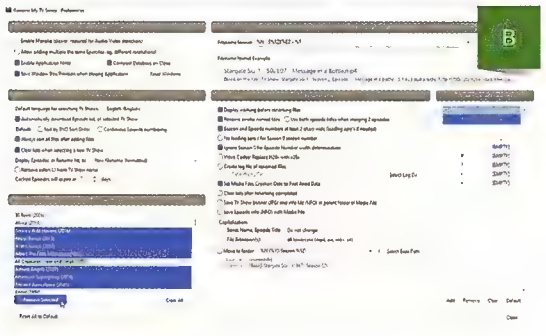
MetaX for Windows
US$9.95
(www.danhinsley.com)

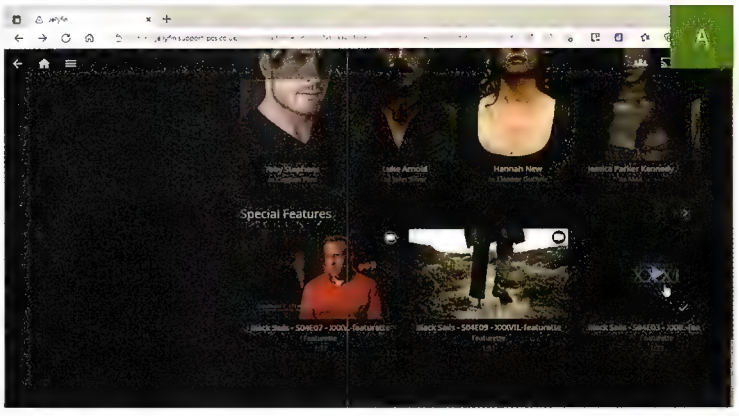
The secret to a perfect media server isn't just the creation of files that play nicely with all your streaming devices. All good media servers, including Plex and Jellyfin, perform what's known as 'media scraping' of online databases such as TheTVDB to furnish you with all the metadata you need – title, episode, synopsis, cast, rating, and so on.

In most cases, this process can be done automatically – all you need to do is correctly name files and place them within the specific folder hierarchy. In this tutorial, then, we'll first look at how to both quickly and easily rename and organise your files to make them identifiable to your media server. We say 'most cases', of course, and while your media server can effortlessly handle the bulk of your movies and TV shows, there will be a few exceptions. For example, if you have collected a lot of supplementary material, such as featurettes, deleted scenes, trailers, and so on, then you will need to tag this content manually.

> "All good media servers, including Plex and Jellyfin, perform what's known as 'media scraping' of online databases such as TheTVDB to furnish you with all the metadata you need."

While you could do this using your media server's own tagging tools, in the second part of this tutorial, we'll reveal a better, long-term solution that makes the job easier and ensures your media libraries look their best.





Movie folder structures

The good news is that media servers, including Plex and Jellyfin, support the same folder structures, allowing you to switch between them more easily. Let's start with movies. While you can simply store movie files directly into a single library folder, if you create a dedicated folder for each one you can store supplements alongside it. Look at the following structure:

Movie Title (Year)
\ Supplement Type

The Supplement Type subfolder can be one of the following (not case sensitive): Behind The Scenes, Featurettes, Deleted Scenes, Interviews, Trailers, Shorts, Scenes, or Other. Any files stored inside these will show up on the movie's own page under Extras listed under their filename (with the supplement type beneath) and an automatically generated thumbnail image. No additional tagging is required as supplements don't get their own page – clicking one simply plays it.

TV folder structures

Things are slightly more complicated for TV shows, but only by the addition of season-level folders. Here's a basic breakdown of what's available:

Show Title
\ Specials
\ Season 1
\ Season 2
\Supplement Type

Both Plex and Jellyfin allow you to insert supplements at one of two levels: Specials is for global supplements, and any files placed here either require being matched to a corresponding entry on thetvdb.com or manually tagged, as we'll see later.

You can also insert supplements at a season level using the same folder naming convention and structure as movies. All Jellyfin clients can display these, while Plex currently only displays these in select clients, including iOS and Roku. As with movie supplements, these appear beneath the list of episodes and require no additional tagging.

Plex users gain a third level of tagging: episode-specific supplements. These sit in the same Season folder as the episodes and must be named as follows:

Show Name – S01E04 – Episode Title-supplement

Replace 'supplement' with one of -behindthescenes, -deleted, -featurette, -interview, -scene, -short, -trailer, or -other. For example, Battlestar Galactica - S04E09 - The Hub-deleted.mp4.

If you're a Jellyfin user, you can still name episode-specific supplements in this way, but they currently appear at the season level **[Image A]**.

quickly rename TV episodes

The next task is to name your files correctly. With TV shows, both Plex and Jellyfin accept variations on a theme, but our recommendation is to stick with the TV Show – S00E00 – Episode Title.mp4 convention. Episode

Title is optional in these circumstances, but it helps make individual episodes easier to identify as files.

You can do this by hand, but a simpler option is to employ the services of a free tool designed for this purpose. Head over to **www.tweaking4all.com/home-theatre/rename-my-tv-series-v2/** to download and install Rename My TV Series 2. Versions for Windows, macOS, and Linux are available.

Once done, launch the program. You'll see it's split into four sections. On the left is the TV episodes search tool. The File Renaming Tips sidebar (below) reveals the basic steps involved in obtaining the show and episode details you need, then matching those episode titles to the relevant files before renaming them.

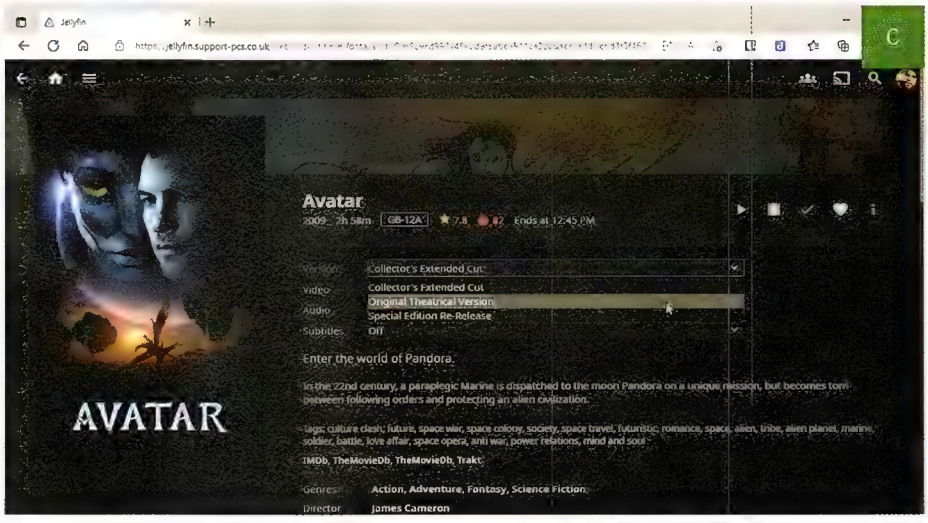
It's all straightforward, and there are some built-in safeguards. If the 'Cannot Rename' button is showing in place of 'Rename Files', then the number of episodes and files don't match. The app will also strip any illegal characters, such as '?', from episode titles before renaming files to ensure they don't cause problems.

Fine-tune renaming settings

Rename My TV Series 2 provides some additional handy shortcuts. 'Copy TVDB ID' link copies the relevant ID number of the show to the clipboard. This can be handy when trying to track down a stubborn show using Plex or Jellyfin's match tools. Instead of trying to search by name, simply enter or paste the TVDB ID for a perfect match every time.

You can also use the 'Export Episodes' button to create a text file listing the episodes by season, while Rename My TV Series 2 also stores previously selected shows in the search history. Click the dropdown button next to 'Search' to access this list alphabetically.

If something isn't to your taste, click the Settings button to change it. There are sections covering the app's general settings, the search tool, and more. You can also edit the search history to remove unwanted entries **[Image B]**, change the overall episode naming format as well as fine-tune other parts of the filename, such as capitalisation or whether to automatically clear lists after the renaming process is complete. See the File Renaming Tips sidebar for more handy hints and tips.



Multiple movie versions

Sometimes you may want, or even need, to accommodate more than one copy of a film. You might, for example, want to provide two versions of a movie at different resolutions, one for streaming locally (such as 4K) and the other for streaming remotely (1080p or 720p HD). Or you may have multiple releases of the same film – a theatrical edition and a director's cut, for example.

Both Plex and Jellyfin can accommodate either type through the following naming syntax, though it's more theoretical in the case of Plex:

Movie Title (Year) – Version name.mp4

Version name can be anything you like, so you could go with Avatar (2009) – 4K stream.mp4 or Avatar (2009) – Director's Edition.mp4 to differentiate between the various versions.

When it comes to accessing movies named this way, however, you're better served as a Jellyfin user. When you browse to the movie's home page, you'll see a conveniently placed Version drop-down menu **[Image C]** allowing you to easily select which version you're looking for.

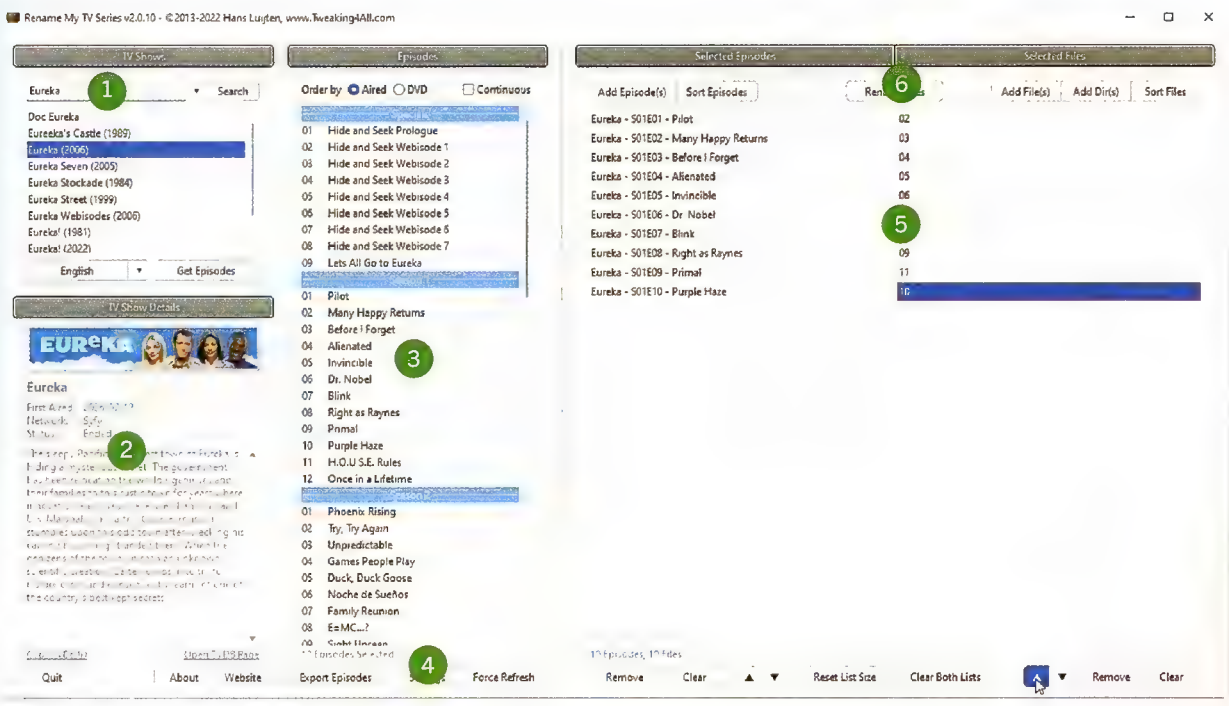
Plex users, however, will find certain clients, including the web client, often display limited information (streaming rate, resolution size) about each version, but won't actually allow you to switch between them.

Other clients, such as the Roku player, can accommodate this, but it's not exactly helpful if you're relying on this approach to differentiate movies by something other than resolution. The sidebar Plex Movie Editions

FILE RENAMING TIPS

Rename My TV Series is a great file-renaming app, and there are several tips and tricks that can help you do even more with it. For example, let's say you have lots of episode-specific supplements – features, deleted scenes, and so on – that you'd like to rename quickly. First, group files of the same type together (so deleted in one folder, featurettes in another). Now, click Settings in Rename My TV Series and add the relevant suffix, such as -deleted or -behindthescenes to the end of the 'Filename format' box. Use the example to verify there's no space between the episode title and the suffix (so Battlestar Galactica – S00E04 - Razor-deleted.mp4). Click Close and match episodes to filenames before renaming them.

You'll also notice some characters are stripped from episode titles in filenames because they're illegal, such as question marks or colons. The Replace Special Characters section of Settings reveals what currently happens with known illegal characters – some are replaced, while others are removed. To change the behavior of a specific character, double-click it in the list and make your changes – for example, you can replace a colon character with a space followed by a dash.



RENAME TV SHOWS QUICKLY

1. FIND A TV SHOW

Type all or part of a show's name and click Search. A list of matching entries from the TVDB website will be displayed.

2. SHOW SUMMARY

Scroll through the list and select the show you're looking for. Verify it's correct using the summary shown here. Click 'Open TVDB Page' beneath the summary to go straight to the website.

3. SELECT EPISODES

A list of episodes, including specials, recorded at TVDB will be displayed. Plex prefers an 'aired' order, so ensure this is selected. Hold Ctrl and click the episodes you wish to highlight.

4. TRANSFER AND SET NAMING CONVENTION

Click 'Add Episode(s)' to transfer the selection here. If you don't like the naming convention (Title – S00E00 – Episode Name) click Settings to change it.

5. MATCH YOUR FILES TO THE RIGHT EPISODES

Next, click Add File(s) or Add Dir(s) to add the files to the list. Match them up using the up and down arrow keys at the bottom of each pane.

6. RENAME EPISODES

Once you're happy that the right episodes are next to the correct files, click the 'Rename Files' button. Click 'Clear Both Lists' to move on to the next batch of files.

reveals an alternative method that's just been added to Plex.

Add metadata to your files

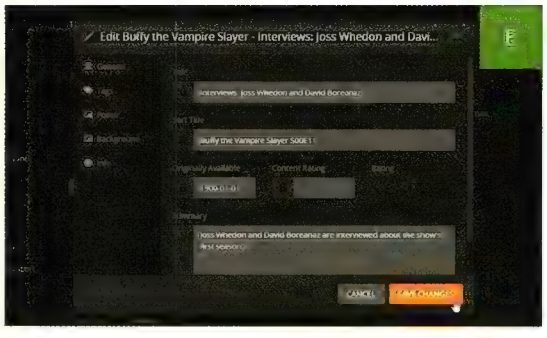
So, you've named your files correctly, and in most cases, your media server should be able to identify them and add the appropriate metadata from online sources.

However, there will always be exceptions, particularly with those TV supplements you want to store in the Specials folder for whatever reason (typically to make them more visible or because they're not related to a specific season or episode).

These latter supplements rarely show up on TheTVDB's database, which means you'll need to manually add whatever metadata you need, and name them so they don't interfere with any existing specials that show up when you perform a search for the show in question.

The best way to avoid any such clashes is to start your episode numbering from 101, such as Buffy the Vampire Slayer – S00E101 – Interviews.mp4, which should ensure that there's no overlap. Now comes the hard part – inputting all the data you need for your media server to display useful information about the supplement in question when it's selected. One way you can do this is through your media server. Browse to the special's own page, then click Edit in Plex, or 'Edit metadata' from the menu in Jellyfin, to make your changes there **[Image D]**.

This is a fiddly approach, however, and your tags are stored by default within the media server's own database, which means you could lose all your carefully curated metadata if anything happened to the server.



Configure MetaX for tagging

The good news is that the MP4 file format allows you to embed metadata and even artwork directly into the file itself. Armed with the right tools, you can incorporate metadata from online databases such as theMovieDB and TheTVDB or populate the tags yourself.

Those tools are MetaX for Windows, and MetaZ for macOS,

which is free from **https://metaz.maven-group.org/**.

Both tools work in a similar way, but we'll focus on MetaX. After launching for the first time, click the Settings button to make sure certain features are enabled. First, if you want your MP4 files to be web optimised (in other words, to start streaming before the full file is downloaded) then make sure you check 'Enable Network Streaming' under the File tab.By default, metadata is embedded into the files themselves; Jellyfin users can tick 'Write NFO File' if you'd prefer to store tags separately (they will be saved to the same folder as your MP4 file, so make sure the NFO files go where the files do to preserve the link). Once done, switch to the Data tab to verify which metadata providers are used. TheTVDB and theMovieDB lead the way here, which covers most bases, but iTunes and TVMaze are also available as a fallback. Click OK.

Download and embed tags

Now click the folder button in the top left and select the files you wish to add to MetaX's queue for tagging and processing. They appear in the right-hand pane, all selected by default, which means any edits apply to all files. You can select a single file to edit, or Ctrl-click to bulk edit a group of files.

To embed existing tags from a supported database into one or more files, make sure they're selected. Assuming the files are named correctly, you should see the name of the movie or TV show pasted into the Search box on the left, so click Search!

A list of matching entries will appear, complete with icons helping you identify which provider they've come from. Select a result and wait a few seconds – you'll see the Info tab in the middle magically fill with metadata (including artwork) from the online database **[Image E]**. Switch to the Video tab where you'll find more information has been pre-filled.

Click on a field and make your changes. If you don't like the artwork, right-click it: choose Select File to pick a replacement or Delete to remove it completely. By default, Plex and Jellyfin will pick a thumbnail from the file to display in its place.

If you've selected more than one file, then each one will fill with information from the search result. Go through each one to check the details. If correct, click the Play button to process the queue and write the tags (and artwork if applicable) into the file.

Add metadata manually

For files where no metadata exists, you can add tags yourself. First, assuming these are all files from the same show, if you select them all, then any tags you enter, such as Show on the Video tab, will apply to all the files simultaneously. Once you've filled in common tags, you can then select each file in turn and enter episode-specific information yourself.

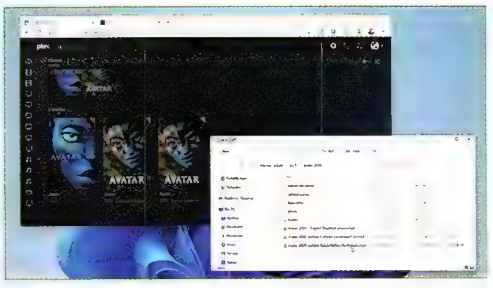
MetaX offers a few handy shortcuts: first, the Title field on the Info tab is actually determined by whatever you enter in the Video tab's Episode ID field. Next, information from the filename will be used to pre-populate fields like Episode #, Episode ID, and so on.

You can enter as much or as little information as you like, but make sure all TV Tags (except Description) are filled on the Video tab, verify the Video Kind dropdown is set correctly (TV Show is the default, but Movie and Music Video are options), then switch back to the Info tab to fill in the Long Description field and add artwork.

Typing descriptions can be time-consuming, so it's worth seeing if you can find a handy descriptive list of supplements online, such as an online wiki or reviews posted on **blu-ray.com** and **bluray.highdefdigest.com**.

You might also want to import chapter titles where applicable to the Chapters tab. If the file has an entry under TheTVDB, try clicking the ChapDB button, which may provide these automatically, but you can input them manually or import them from elsewhere too.

Again, once you've set up the files as you wish them to appear on your media server, click the play button and wait for the files to be written to disk. ■



PLEX MOVIE EDITIONS

While Jellyfin handles multiple movie versions and editions using the same suffix filename style (see step five), Plex is less flexible with this approach. Plex prefers you to use suffixes for multiple versions of the same file only. This means your client either picks the best option based on available bandwidth or lets you choose from a list that only displays each version's resolution and bandwidth.

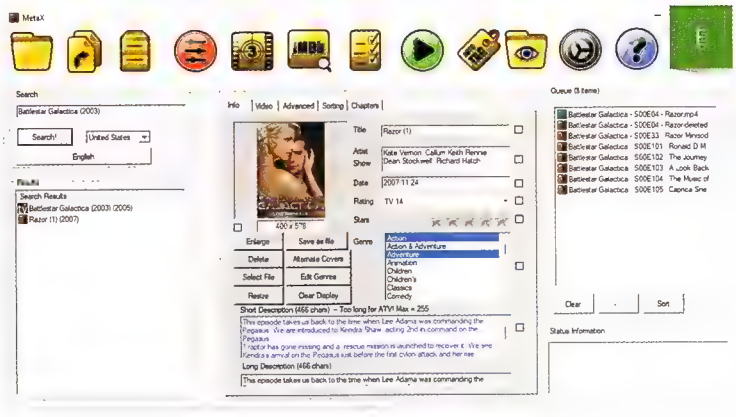
If you'd like to offer multiple editions of a film, you're advised to try a different naming convention. Although Plex recommends separate directories for each edition, you can store them all in the same directory:

Avatar (2009)
Avatar (2009) {edition-Collector's Extended Cut}.mp4
Avatar (2009) {edition-Special Edition Re-Release}.mp4

If you then want to store multiple versions of each edition, you'll need to adapt the naming convention again:

Avatar (2009).1080p.{edition-Collector's Extended Cut}.mp4
Avatar (2009).SD.{edition-Collector's Extended Cut}.mp4

The result is that each edition is listed separately in your library. You could then consolidate them all into a single collection if you wish. Sadly, the naming convention isn't currently compatible with Jellyfin, which simply lists all three movies as separate entries of the same movie with no specific edition listed for each.

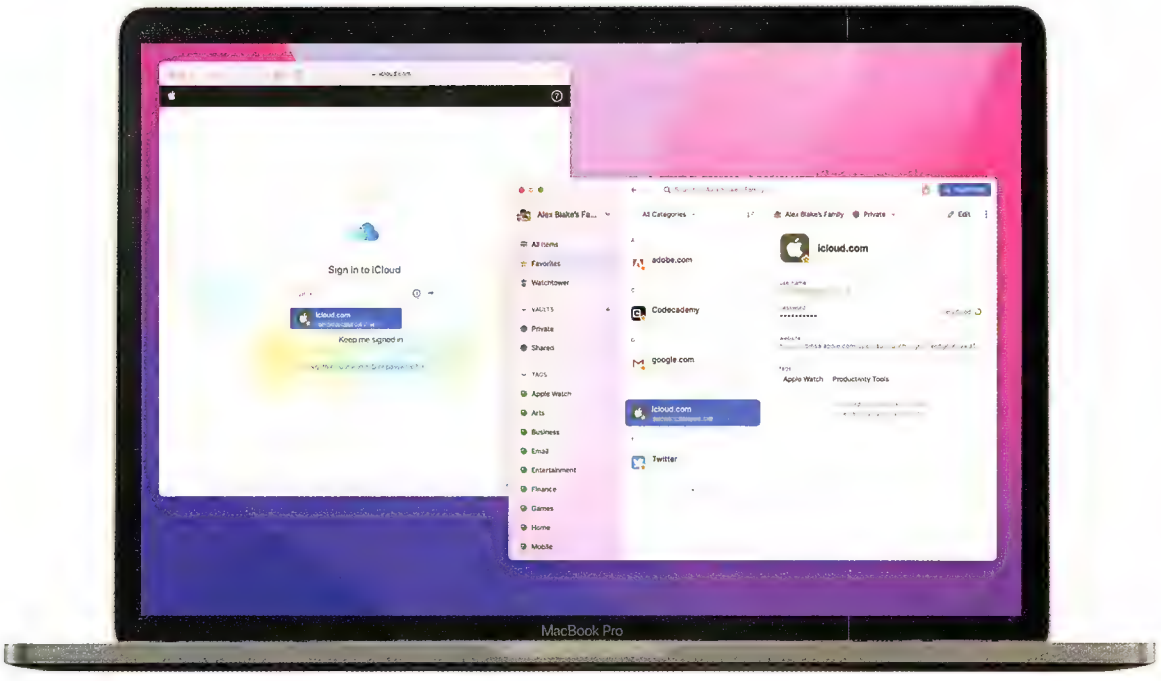


© Microsoft

MAC OS

Super-strength passwords

1Password 8 for Mac keeps all your precious data under lock and key.



IT WILL TAKE
10 minutes

YOU WILL LEARN
How to secure logins, sensitive info, private notes, and more

YOU'LL NEED
1Password 8 for Mac, macOS 10.15 or later

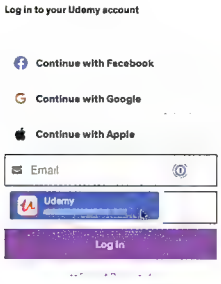
We all know we need to use strong, unique passwords for our accounts, but doing this for every single login is a slog. No wonder so many people reuse 'Password123' for everything.

But there's a better way – use a password manager. 1Password is one of the best there is, and it can generate and save strong, unique passwords so you never even need to think about them. All you need to remember is a master password – and if you have an Apple Watch, you can unlock the app with that instead. It even goes beyond passwords. The app can save your addresses, vaccination dates, driver's licence, private notes, and more. It even works with SSH keys and one-time passcodes. That makes it a one-stop shop for all the info you want to keep safe.

In this tutorial, we'll show you how to use 1Password 8 and its Safari extension (which you should install before starting) to ramp up your login security. It's way easier to start using than you think.

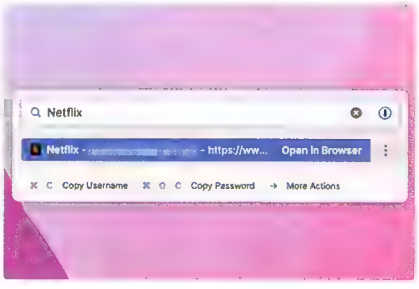
Alex Blake

HOW TO MASTER THE BASICS



1 AUTOFILL ON WEBSITES

Install the 1Password Safari extension. On a website where you have a saved login, click the 1Password icon in the form field, then choose your login. Its username and password will be automatically filled in for you.



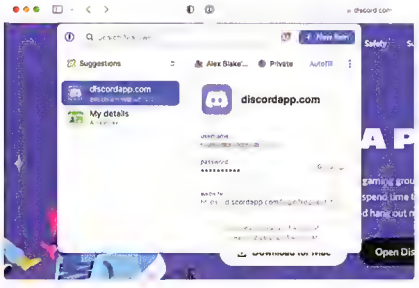
2 QUICK ACCESS

Press up-command-Space bar to open 1Password's Quick Access bar. This works like Spotlight – search for a login and the entry appears. You can copy the password, autofill it if you're on the right website, and more.

3 AUTOFILL IN APPS

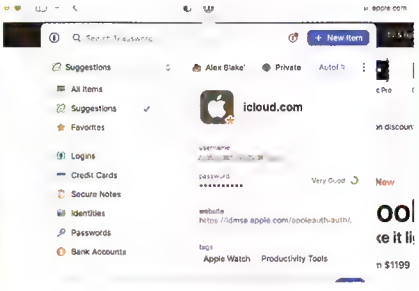
Password autofill also works in apps and system prompts. Press up-command-Space bar and Quick Access should show the app's login. Press up-return to autofill it. 1Password even clicks the Sign In button for you!

HOW TO USE 1PASSWORD IN SAFARI



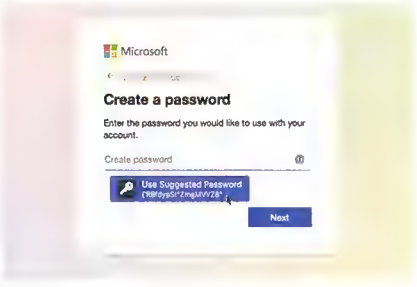
1 VIEW A LOGIN

When you click the 1Password button in Safari, it will show your current website's login (if there is one saved). Click Autofill to enter its info, or click the '…' button to edit the login, add it to favourites, and more.



2 BROWSE YOUR INFO

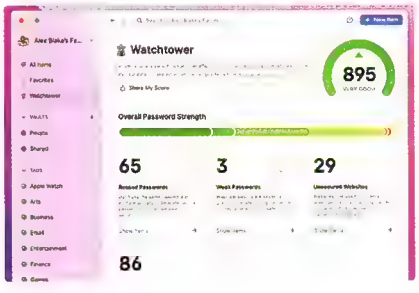
On the left, click Suggestions. Here you can browse saved information in different categories, such as credit cards and your personal details. You can also view your favourites and all your saved items at once.



3 SAVE A NEW LOGIN

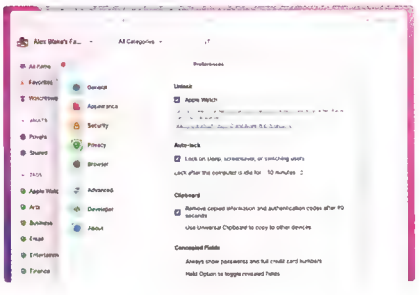
When you register for a new website account, 1Password can save the details. When you get to the password field, click Use Suggested Password. Add any extra details you need in the pop-up window, then click Save.

HOW TO GO DEEPER



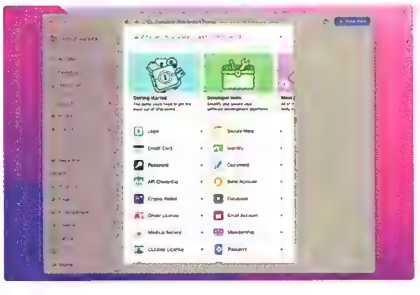
1 VIEW THE WATCHTOWER

In the sidebar, click Watchtower. This rates your passwords and shows suggestions to improve. Click Show Items next to the suggestions; click an item in the list, then follow the on-screen instructions to secure it.



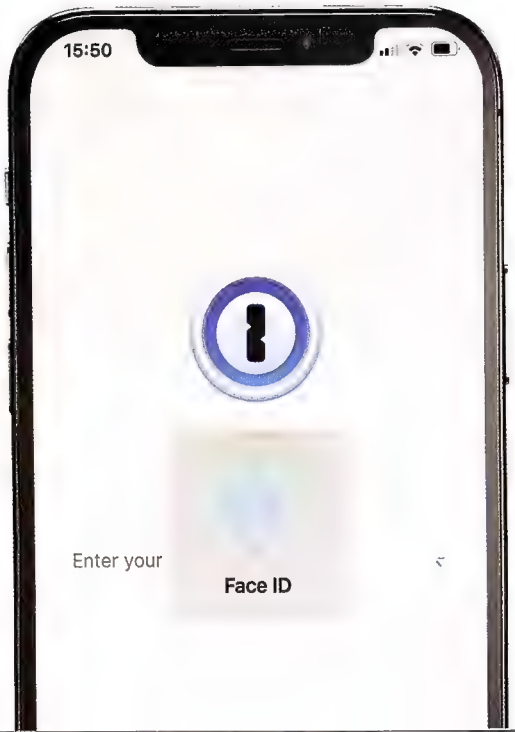
2 APPLE WATCH UNLOCK

First, ensure Apple Watch unlock is enabled in System Preferences > Security & Privacy > General. Then click 1Password > Preferences > Security and tick the checkbox next to Apple Watch to unlock the app with your Watch.



3 MORE THAN PASSWORDS

1Password 8 can store more than just email addresses and passwords. Click New Item in the top right, then choose a category. There are options for driver's licences, passports, medical records, payment cards, and more.



1PASSWORD 8 ON IOS

Working together with the Mac app

1Password 8 also has an iOS app. Mac features like Watchtower are present and accounted for, as are favourites and collections. As well as syncing all your logins across your devices, it also has some iOS-specific features. For example, the new version of the app lets you show, hide, and rearrange home screen items, making it easy to find what you need. And you can unlock the app using Face ID, giving you an incredibly secure way to keep your logins safe. Use it in tandem with the Mac app so you always have your saved items to hand.

"You can unlock the app using Face ID, giving you an incredibly secure way to keep your logins safe."

LINUX

Track down files and folders instantly

'Work smarter, not harder' advocate Nick Peers reveals how to use a tool to transform the way you search for files and folders on your PC.

QUICK TIP!
We've barely scratched the surface of FSearch's powerful syntax – visit **https://github.com/cboxdoerfer/fsearch/wiki/** Search-syntax for a rundown of how it works, including guides to modifiers and functions.

The ability to search your hard drive for files and folders is a critical part of any OS. Ubuntu's file search exists within the Files tool itself, but it's very basic. You type all or part of a keyword and the currently selected folder or drive is searched, with any matching results displayed – after a short pause.

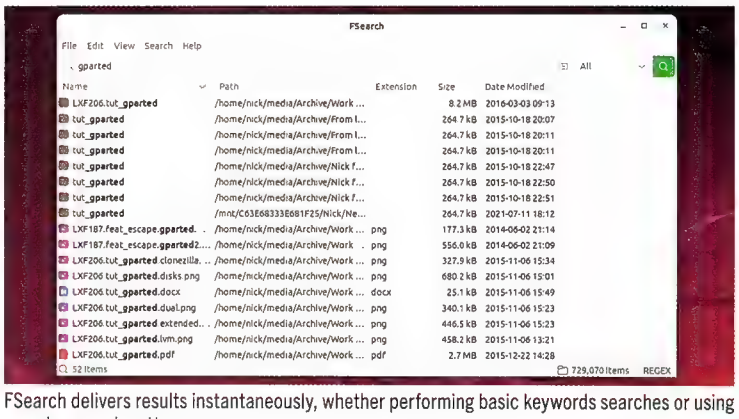
Eliminating that pause and widening the search to cover more of your storage requires choosing a different search tool – one that's able to build an index of your files and folders that updates as changes are made, and which provides the search tool with the ability to return results instantaneously. But that's not all a good search tool should offer. What happens if you only remember part of a name, or aren't sure what certain parts of the filename are?

One such tool is FSearch (**https://cboxdoerfer.github.io/fsearch**). It delivers results in the blink of an eye, and supports a wide range of search tools, from support for wildcards and RegEx expressions that don't require precise search terms, to filters and sort tools to help narrow results further when required.

FSearch's website reveals how to install the standalone tool across a wide range of distros and flatpak; Ubuntu users simply need to add the program's own repository prior to installation:

```
$ sudo add-apt-repository ppa:christian-boxdoerfer/fsearch-stable
$ sudo add update
$ sudo apt install fsearch
```

Once installed, *FSearch* is accessible via the launcher. By default, it'll index everything in your home folder – start typing a few letters and you'll see it immediately starts returning results, with your search terms highlighted within the file and folder names listed. Double-click a file to open it, or right-click it for more options, such as opening it in a specific application.



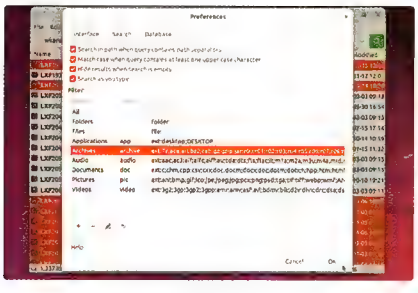
FSearch delivers results instantaneously, whether performing basic keywords searches or using complex search patterns.

You can also select multiple results. Choose Edit> Select All, or manually click and select. There's also an option to invert your selection via the same Edit menu.

To the right of the search box you'll see an 'All' dropdown. Click this and you'll see options for filtering your search to show only one of the following types: Folders, Files, Applications, Archives, Audio, Documents, Pictures and Videos. They're all self-explanatory, but you can see what file types each one covers by selecting Edit>Preferences>Search tab.

Here you can edit what file types are supported for each type, along with a macro name. The

BUILD YOUR OWN FILTERS



1 ADD AND EDIT FILTERS

Open FSearch and choose Edit> Preferences>Search. To change an existing filter, click Edit; to add a new one, click the + button. The Name appears in the Filter dropdown; the Macro is the command you use to invoke the filter from the Search bar.

2 SET YOUR QUERY

Type keywords to filter your search, ticking 'Match case' to make them case-sensitive, or 'Enable regular expressions' to build a more sophisticated filter involving RegEx. Use an online tool like **https://regexr.com** to help build your queries.

3 MORE OPTIONS

The 'ext:' line as found in preset filters like Documents reveals how to set up file-type based filters. Finally, to create a filter that restricts your search to a specific folder, tick the 'Search in path' box and type the full path into the Query box.

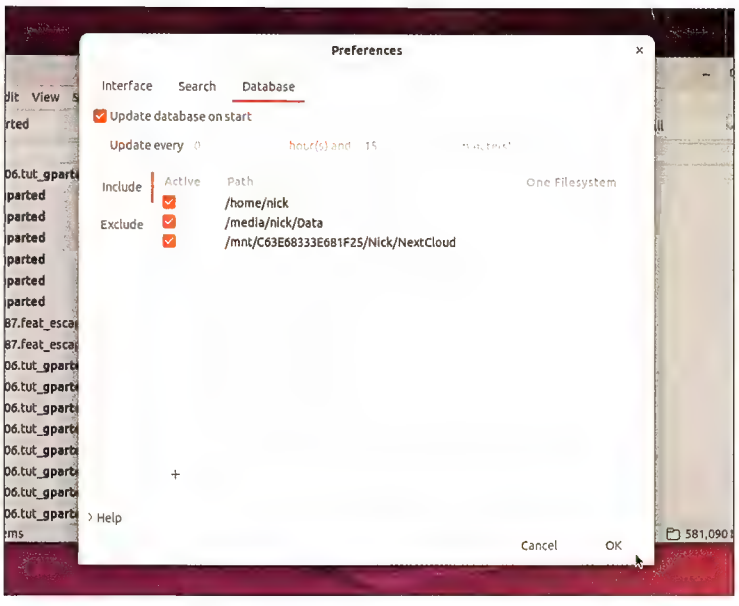
macro enables you to search using that filter directly from the Search box. Type the filter's macro followed by a colon and your search terms, such as **doc: APC** to perform a search for documents with names containing APC. You can edit these categories and add your own filters from scratch – see the step-by-step guide (below left) for details.

The Art of the Search

In addition to FSearch's support for boolean operators (**AND**, **OR** and **NOT**), there's support for using wildcards to find files and folders with similar, but not identical, names – or to compensate for your faulty memory. These follow the usual rules: * can substitute multiple characters, so **wh*** would return **what** and **why**, while **w*t** would return both **what** and **wet**. For single characters, use **?** so **w?v** would only match three-letter words beginning with w and ending in v – **wav** but not **wave**. You can mix and match, so **w?v*** for example would match both **wav** and **wave**.

Another handy wildcard is the square bracket. This enables you to narrow the focus of your search, so **c[ae]ll** matches **call** and **cell**, but not **cull**. You can also specify a word range using a hyphen: **c[e-u]ll** would find **cell**, **cull** and everything in-between. Use the exclamation mark to exclude characters: so **c[!a]ll** matches **cell**, **cull** but not **call**.

FSearch also supports regular expressions (see box, below) while the Quick Tip reveals how to master other supported search syntax.



By default FSearch indexes your Home folder only, but you can add additional folders and drives via Edit> Preferences.

Now you've mastered the basics of how FSearch works, and seen how it can help you find those deeply buried files that much quicker, it's time to fine-tune the program to deliver even better results.

First up – if you're someone who doesn't consolidate all their files in their Home folder (or even on the same drive), then you'll need to add those extra locations to FSearch's database so it knows to index them. This is an intensive process, and the more files you need to index coupled with the relative speed of your hard drive will determine how long the initial indexing process will take.

To add these locations to the database, choose File> Interface and switch to the Database tab. Click + to add each folder or drive you wish to index.

As soon as you click OK, the selection will be indexed, and the index's progress will be displayed in FSearch's status bar.

When configuring your folders, you'll notice an Exclude option on the left. You can use this to exclude specific folders and file types from the index, and automatically exclude hidden files and folders. Simply click + to select your unwanted folders, or enter the file names or types to exclude in the 'Exclude files:' box, separating each one with a comma.

FSearch is configured to only update its index when you launch the program. If you plan to leave it open for hours at a time, you might want to configure it to update periodically: tick 'Update every' and set the hours and/or minutes between each scan. Remember, however, that indexing puts pressure on your filesystem and could slow down your system while it's running. ■

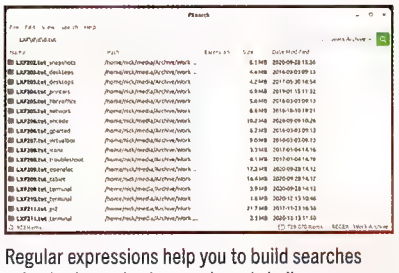
EXPRESS YOUR SEARCHES

FSearch also supports Regular Expressions (RegEx) for advanced search terms. RegEx is disabled by default – press Ctrl-R to enable/disable it as required, and you'll see REGEX is listed in the status bar when it's switched on.

Why use RegEx? One reason is if existing boolean operators and wildcards don't meet your exact needs. RegEx supports these terms – albeit in a different way (use | in place of OR, for example) that enables you to build more sophisticated searches.

Take **?** and * for example. With RegEx, **?** is used to indicate zero or one occurrences of the preceding character – so **armou?r** would match both UK (Australian) (**armour**) and US (**armor**) spellings. Similarly, * works to indicate zero or more occurrences of the preceding character, while + matches one or more occurrences – so **fee*d** would match both **fed** and **feed**, but **fee+d** would only match **feed**.

If you're wondering, the full stop (**.**) character replaces the question mark (**?**) as a single-character wildcard. If you want to restrict the wildcard to a specific type use **\d** for a single number, **\w** for an alphanumeric (A-Z, 0-9) character, or **\W** for a symbol. Finally, to emulate the asterisk (*) wildcard in RegEx, use **.*** instead (so **r.*d** to match **rod**, **red**, **reed**, **read** and so on).



Regular expressions help you to build searches using both precise keywords and similar ones.

PI GO

Using the GPIO with Go

Les Pounder is ready to go! By which we mean he's keen to try out the Google-developed alternative programming language to Python.

YOU'LL NEED THIS

- Raspberry Pi
- The latest Raspberry Pi OS
- 3 x LEDs
  3 x 220 Ohm Resistors (Red-Red-Black-Gold)
- 6 x Female to male jumper wires
- Breadboard
- The code: https://github.com/lesp/LXF-Go-Raspberry-Pi-GPIO/archive/refs/heads/main.zip

GENIUS TIP!

Sometimes you'll forget a command, but don't worry because "go help" is there to save the day. Furthermore, error messages are very helpful, and even point out what went wrong!

Think Pi coding, think GPIO, think Python, right? Python isn't the only way to access the GPIO. In this tutorial we'll use Go, a flexible and easy-to-use alternative to Python. We'll learn how projects are built, how to import modules of code and write projects that interact with the Raspberry Pi's GPIO. Before we install Go, it's best practice to ensure that our system is up-to-date. Open a terminal and run the following commands to update the list of repositories and then install the latest software. Note: this can take a while.

```
$ sudo apt update && sudo apt upgrade -y
```

Visit **https://go.dev/dl** and download **go1.19.linux-armv6l.tar.gz** to your **Downloads** directory. At the time of writing this was the latest version of Go for Arm-based 32-bit CPUs.

In a terminal, navigate to your **Downloads** directory. Run a command to delete any previous Go installations, and then install the downloaded package. We'll need to perform the install using sudo because we are making changes to the system.

```
$ cd Downloads
$ sudo rm -rf /usr/local/go && tar -C /usr/local -xzf go1.19.linux-armv6l.tar.gz
```

Next we need to export a path environment, a means for the OS to find the files necessary to use Go. There are a few ways to do this. A permanent means is to edit **/etc/profile**, adding **:/usr/local/go/bin** to the end of line 7 (the start of an else condition) so that the line reads

```
else PATH="/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin:/usr/local/games:/usr/games:/usr/local/go/bin"
```

The quicker, non-invasive way is to declare the path environment in the terminal. But the system will forget this when we reboot.

```
export PATH=$PATH:/usr/local/go/bin
```

The final installation step is to check that Go has installed correctly. In the terminal use **go version** to check. It should report that Go version 1.19 for linux/arm is installed.

> "In this tutorial we'll use Go, a flexible and easy-to-use alternative to Python."

Hello Go!

To understand how Go works we need to build a quick Hello World tool. By doing this we can prove that our install works, and that we understand the basics of the language.

In a terminal,navigate to your **home** directory and create a new directory called **hello**. Then move into that directory.

```
$ cd
$ mkdir hello
$ cd hello
```

Next we enable dependency tracking, a means to manage any modules that we import into our project. This is stored in a file called **go.mod**.

```
$ go mod init example/hello
```

Now we create the file that will contain the project code. Create a new file, **hello.go** using your preferred text editor. The project code is made up of a main package, which is a way to group functions made of files from the project directory we just created.

```
package main
```

We then import the **fmt** text formatting package. This is part of the standard Go library.

```
import "fmt"
```

Finally we create a main function that will run by default and print a message to the console.

```
func main() {
  fmt.Println("Hello, World!")
}
```

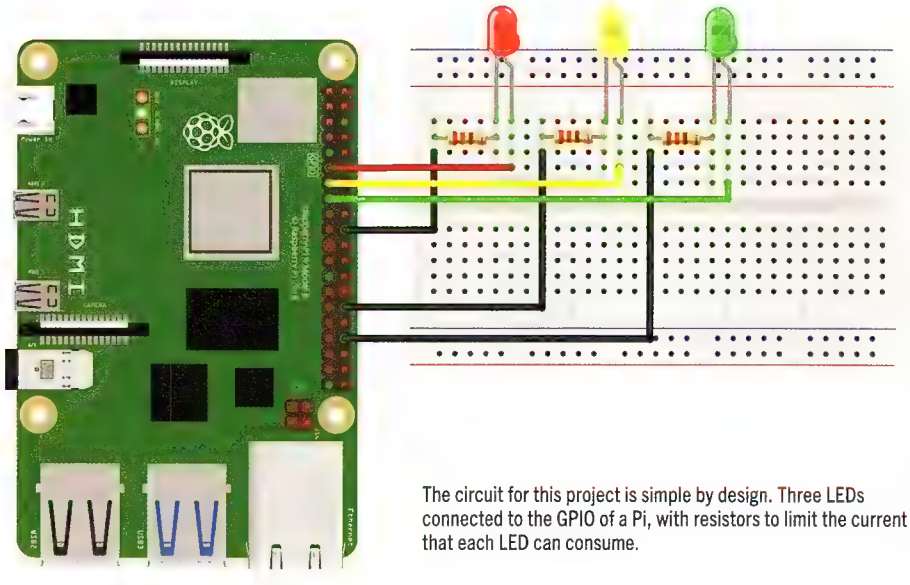
Save the file and in the terminal, inside the directory we created earlier, run the project code:

```
$ go run .
```

Blinking LEDs with Go

On to the fun part! Blinking LEDs is the hello world of electronics, and it also provides a means to check that we understand the process, and that our configuration is correct. Our goal is to blink three LEDs, connected to GPIO pins 17,27 and 22 (see diagram, left) using Go.

Via the terminal, in your home directory create a new directory called **blink** and then change directory to it.



The circuit for this project is simple by design. Three LEDs connected to the GPIO of a Pi, with resistors to limit the current that each LED can consume.

```
$ mkdir blink
$ cd blink
```

Enable dependency tracking for the project.

```
$ go mod init blink
```

In your preferred text editor create **blink.go**. The first line of code is the main package, which uses the files from our project directory.

```
package main
```

Next we import the modules of code, but this time we have additional modules for handling returning to the OS, adding pauses to the code, and a link to a Github repository that contains the GPIO module.

```
import (
    "fmt"
    "github.com/stianeikeland/
go-rpio/v4"
    "os"
    "time"
)
```

Next, we declare the variables that we'll use to refer to the LEDs on GPIO pins 17,27 and 22. The GPIO module is called and the pin reference given. These are all stored as variables that we can refer to by their name.

```
var (
    red = rpio.Pin(17)
    yellow = rpio.Pin(27)
    green = rpio.Pin(22)
)
```

The main function is run by default, and its first task is to check that we can assess the GPIO. If we can't, the code will end and close the attempted GPIO connection. In the past this was reserved for sudo/root users, but the latest kernels enable other users to access it.

```
func main() {
    if err := rpio.Open(); err != nil {
        fmt.Println(err)
        os.Exit(1)
    }

    defer rpio.Close()
```

We then declare that our LEDs are output devices.

```
    red.Output()
    yellow.Output()
    green.Output()
```

The final part of the code is a for loop, but this isn't a for loop that iterates for a set number of times. Rather, this for loop is really a while True (forever) loop that will turn an LED on/off before pausing for 200 milliseconds, then toggle the next LED in the sequence, with another pause, then the final LED, then a pause.

```
    for true {
        red.Toggle()
        time.Sleep(time.Second / 5)
        yellow.Toggle()
        time.Sleep(time.Second / 5)
        green.Toggle()
        time.Sleep(time.Second / 5)
    }
}
```

Save the code and return to the terminal. Before we can run the code we need to authenticate the GPIO module for use. In the terminal run:

```
$ go mod tidy
```

We can now run our GPIO project code. Press Enter to start and Ctrl-C to stop and exit the code.

```
$ go run .
```

Right now we have a very cool introduction to Go for the GPIO, but there's something else we can add to this project – something that will make it portable!

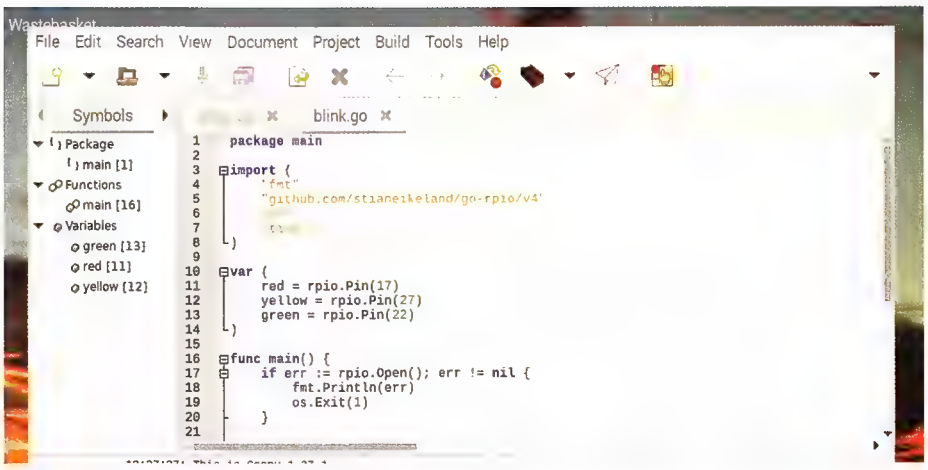
Go projects can be built into single executables using just one line of code. In the terminal run the following build command to create an executable file from our project code:

```
$ go build blink.go
```

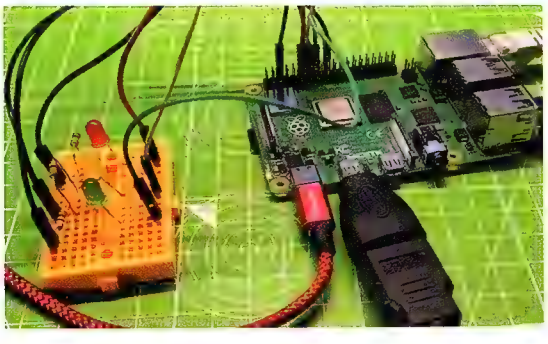
To run the executable we just call its name, prefaced with ./ :

```
$ ./blink
```

You've just taken your first steps with Go on the Raspberry Pi. If you want to find out more, take a look at the boxout (below). ■



We have two favourite editors on the Raspberry Pi. For the GUI we love the simplicity of Geany, but in the terminal, nano is our go-to tool.



Starting out with electronics and Go, Hello World and LEDs are the best way to get the grounding that we need for larger projects.

GO FURTHER

Go, an open source programming language, was created at Google in 2009 by Robert Griesemer, Rob Pike and Ken Thompson. If you're already familiar with programming, you'll notice that its syntax is similar to C, but Pythonistas will spot that it's as easy to read as Python. Go is sometimes referred to as GoLang. This is due to its former golang.org domain name. Trust us, the name is Go.

The Go project is officially located at **https://go.dev** and this is where we can find a rich resource of documentation and examples. Along with learning resources we find the package search page **https://pkg.go.dev**. Unlike Python, where we need to install packages using our OS package manager or via the Python package manager, pip, Go can use Github repositories that contain all of the modules necessary. We used **github.com/stianeikeland/go-rpio/v4** in our project code. Go handles the import and all we need to do is make sure we run go mod tidy before running or building our code.

Go may not be as popular as Python, but that doesn't mean it's unheard of. Google plays a large part in its support, and companies such as American Express, Cloudflare, Dropbox and Netflix use Go in their infrastructure.

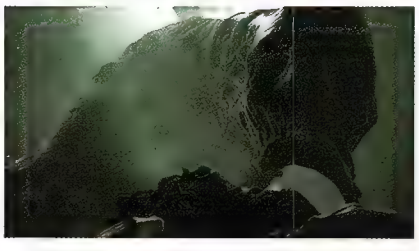
GAMES

Scorn

Will you help the Nasty Man escape from Sphincter Island?

■ $59.99 | PC, XBS/X | ebbsoftware.com

apc HIGHLY RECOMMENDED



In my favourite moment, late in *Scorn*, you transition from the industrial underbelly of this forgotten civilisation to its alien and terrifying, yet also still somehow mournful, regal capital. The entire game up until now you've seen the gruesome brown machinery of this ancient people churning and grinding to do something, ripping familiarly human-like beings apart, sometimes while they're still alive, for some unknowable purpose.

Here in the Polis, you see a decaying cathedral adorned with colossal statues of these same beings, some taking heroic poses, others cradling red, glowing wombs, and many of them copulating. How did this civilisation digest the contradiction in how it represented itself versus how it treated its people?

The core gameplay loop reminds me most of *Portal*, or even a more gruesome take on *Myst*. You enter a new area and have to slowly pick your way through, soaking up the creepy ambience and sussing out the function of the various grotesquely biological apparatuses left behind by this lost civilisation. *Scorn*'s protagonist looks to be a member of that civilisation, maybe the last one left after everyone else went to the body horror Rapture.

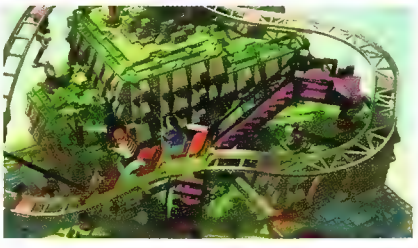
Scorn's combat is reminiscent of a classic *Resident Evil*. You move very slowly, enemies hit hard, and more than two facing you at once is overwhelming. The bread and butter of your arsenal is a phallic melee plunger thing that has to cool off every two shots, though you later gain access to other gross weapons too. I enjoy *Scorn*'s combat, if enjoy is the right word. It's tense like old-school survival horror, and it always feels like I'm just barely making it by the skin of my teeth as I hustle to avoid attacks, weaving close to these weird flesh monsters to bop them with my penis gun.

Unfortunately, that punishing combat definitely exacerbates those checkpoint woes I mentioned. Before that glitch in the last level harshed my profound, cosmic horror vibe, I also lost about an hour and a half of playtime partway through the game. After a long *Scorn* sesh ending with a real bastard of a puzzle, I died and respawned just a few minutes prior. Loading back into the game later, I discovered I had to redo the entire preceding chapter, puzzle and all. I feel like a reasonable developer-side solution would be to have a single rolling checkpoint save slot accessible from the load menu.

Checkpoint shenanigans, short runtime, and all, I think *Scorn* is worth the price. It's striking, unique, and it doesn't overstay its welcome. *Scorn* could have certainly worked as a lower-fi, *Haunted* PS1-style project, but its commitment to the grotesque genuinely benefits from high-end, modern rendering.

Checkpoint woes and a short runtime couldn't keep this body horror sci-fi game from burrowing into my skull.
Ted Litchfield

★★★★☆



LEGO: BRICKTALES

A satisfying, imperfect new step forward for Lego games.

■ $42.95 | PC, XB1, PS4, Switch | thunderfulgames.com/games/lego-bricktales

It's one thing to place random Lego bricks in an aesthetically pleasing way; it's another thing entirely to, as *Bricktales* bids its players to do, construct architecturally-stable structures out of nothing but bricks and basic guidelines.

You're tasked with collecting five 'happiness crystals' to renovate an abandoned park before the nearby mayor comes to evict him. You can find these crystals in each of the five stages you travel to in the course of the campaign, and the general flow is the same throughout: arrive in a new place, figure out what's making people in the area unhappy, solve that problem by building things out of Lego, collect the happiness crystal, return and build some theme park rides. Lather, rinse, and repeat. The nice part about going through each stage is that you notice little hidden items that you can't get yet unless you unlock a special power.

> "Figure out what's making people in the area unhappy, solve that problem by building things out of Lego"

ClockStone Studio, *Bricktales*' developer, is best-known for its Bridge Constructor series, and it brings the general vibe of that prior series into their work here. When you enter a new puzzle, you are given all of your available parts, an area to build them in with upper and lower bounds, and a few instructions, like "build the bridge so that 1) nothing breaks and 2) the test robots can cross it". You're then free to build whatever you feel like that meets those conditions.

Sometimes you have to subject your build to a pretty brutal physics battery, like watching a perch for some parrots swing wildly around in an attempt to keep balanced, or a one-ton weight drop directly on the one place you forgot to fortify. Other times, the only instruction "build a perfect pyramid" has you pulling your hair out as you try and fail repeatedly to do what it says, with no hint system to help you. But I think all of its elements come together to help *Lego: Bricktales* stand triumphantly on its own two janky, shaky legs.

Manages to build a lot of fun despite some structural shakiness and tricky puzzles.

Kaile Hultner

★★★½☆

CARD COWBOY

Life is a pack of cards.

■ Free | PC, Mac | bit.ly/CardCowboy

This text-based adventure, *Card Cowboy*, is a narrative sandbox that sets you off on a revenge mission – a stranger has seduced your mum, murdered your dad, and perhaps worst of all kicked your dog – but how you achieve it really depends on what's in your hand.

There's an event at various locations – be it an oasis out in the wilderness, a farm, church, or town – and every event holds a number of logical or silly solutions. To pick one example, after meeting a farmer's son/daughter you could play your Horse card to take them for a romantic ride. This plops the Wedding card into your hand, which can then be exchanged for a Wife or Husband down the line. But you could also play your Money card, which your love interest interprets as an insult. You're given a Whisky card to help drown your sorrows. You can sort of guess the outcomes of both these scenarios, but *Card Cowboy* is at its best when you use the more ridiculous cards, just to see what happens.

A funny *Wild West* parody with a nifty card system that rewards experimentation – just not as much as I'd like.

Tom Sykes

★★★☆☆

ZOLF

Now watch this warp drive in sci-fi golfing game.

■ Free | PC | bit.ly/GolfGame

A submission to (and winner of) this year's LOWREZJAM, *Zolf* is a glorious mash-up of golf and 2D platformer, where you solve puzzles with the aid of your tire iron and a little ball-shaped alien. After crash-landing on a planet, your only hope of escape is to repeatedly whack the alien with a slender stick – punting the critter to too-high ledges, where it can get to work flipping switches that will let you progress. You control both the golf-playing humanoid and the cute, rotund critter, and there's some pleasant, puzzling as you switch between the pair to get past each screen.

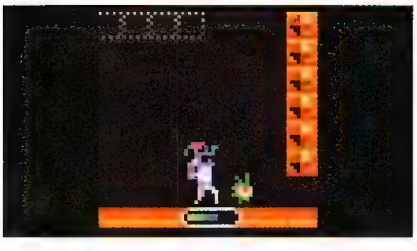
It's not tough puzzling, but it is a joy to play out, as the game introduces new elements to keep things interesting. It's also a bit of a looker, its diminutive pixel art brimming with character, and an imposed resolution limit that doesn't get in the way of the action.

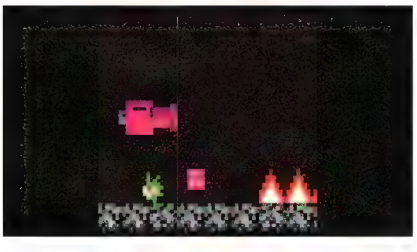
At the touch of a button you can zoom in or out, to a view that makes it easier to plan your trajectory. It makes the golf part actually doable, and satisfying too.

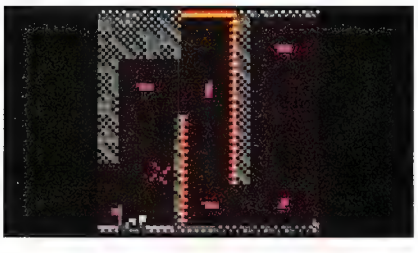
A golf game that feels bigger than the borders of its tiny window.

Tom Sykes

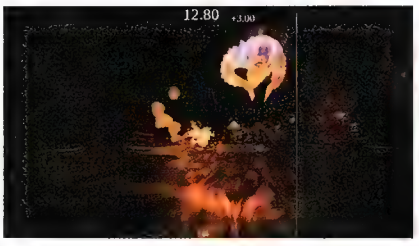
★★★☆☆







apc EDITOR'S CHOICE



HYPER DEMON

A demon appeared to them and they were terrified.

■ $13.49 | PC | hyprd.mn | hyprd.mn

Have you ever wondered, what would it be like to fall into a black hole? Then this might be a game for you. Not because it answers the question, but because it offers an experience akin to dancing on reality's edge. Perspective, time and space all break down as the game encourages you to push beyond your limits. Which is funny for a game about chasing high scores and shooting monsters, something games have done since their inception.

Hyper Demon isn't about surviving. It's about thriving. Scoring this time around isn't based around how long you can live but about how quickly you can put down ethereal beasts. The more you can cut down in the shortest amount of time, the higher you score.

From first-person perspective you shoot daggers from your ethereal hand with two firing modes, a machine gun and shotgun blast, now complimented by pick-ups that can be used as laser beams. Though these lasers can be used to detonate pick-ups with devastating fireworks. Moving around involves more than hopping, you can fire yourself into the air with a blast at the ground and dash to dodge out of the way of foes.

> "Overseeing a race is the big thing, and it's not a passive experience"

The visuals and audio are something you'll either find alluring or off-putting depending on your persuasion but it's not as impenetrable as it seems in screenshots. Once you're in control, that storm of colour and light is yours to wield.

That's the challenge at the core of the game. Tension between the known and unknown. Learning how to go from flailing helplessly in the dark to the destroyer of worlds. Chasing increasing power is the hook of so many action games, a fantasy so baked-in it barely even registers any more. It's expected. *Hyper Demon* makes it feel unexpected. You're not gathering better weapons, not trading in pistols for rocket launchers. You are simply learning. Everything that makes you better at the game is knowledge, there are no tools that can be taken away. Because you are the *Hyper Demon*.

Hyper Demon is a masterpiece that will have you soaring like an angel through the depths of hell.

Samantha Greer

★★★★½

UNCHARTED: LEGACY OF THIEVES COLLECTION

Brings Drake's best adventure to PC.

■ $74.95 | PC | playstation.com/en-us/uncharted

Uncharted, I've missed you. The reckless personalities, lush environments and ridiculous action set-pieces are unlike anything else we have in games, and coming back to the series with this PC port of the fourth game and its standalone expansion (*The Lost Legacy*) has been a pleasure.

Where Lara Croft claims she's just an archaeologist, despite her chaotic exploits, Drake and crew are self-confessed thieves, mercenaries and rogues, with silver tongues and dark pasts. In his wake, history is destroyed one collapsing temple at a time, but in the end he always makes the right choice... and ends up no richer than when he started. They're thrilling adventures – and *Uncharted 4* is the best of all of them.

All the action has aged wonderfully well. As someone who plays a lot of FPS games, I prefer shooting and aiming with a mouse for the combat sections, which are actually more frequent than I remembered. The climbing mechanics are still lovely puzzles you solve as you work your way to a goal, finding the fun in architecture better than the recent Assassin's Creeds, and the driving sections are still tense and exciting. Graphically, even going in with the expectation that this is a studio that excels at visuals, it'll still take your breath away.

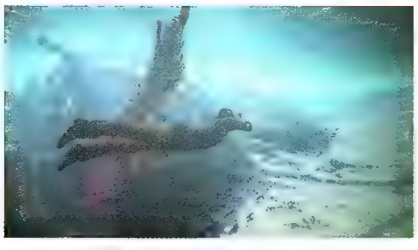
Six years after its original launch, this is still the best action-adventure game out there. It's a gorgeous, first-class travel package that takes you physically and emotionally to incredible places. The beginning of each area or chapter feels like a red carpet rolling out in front of you, inviting you to experience something new each time. Take in the frozen earth of Scotland, the colourful savannah of Madagascar and the dry evening breeze of Italy. Uncharted takes you somewhere and turns it into a playground of chaos to mess around in (and probably blow up on your way out of it).

> " It's a gorgeous, first-class travel package that takes you physically and emotionally to incredible places."

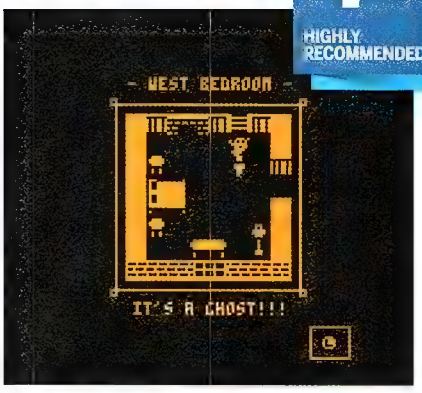
Nathan Drake's last outing in the *Legacy of Thieves Collection* is still at the top of the action-adventure genre.

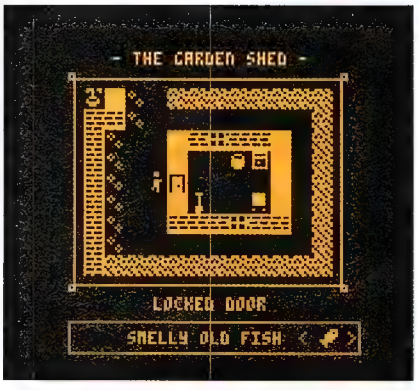
Imogen Mellor

★★★★☆



apc HIGHLY RECOMMENDED





THE SPOOKY HOUSE

Burgle an abandoned mansion.

■ Free | PC, Mac, Linux | bit.ly/TheSpookyHouse

Though it looks small, *The Spooky House* is actually a sizeable game, full of items to pick up and places to use them, with stripped-down inventory management that makes it playable with a single button. And, well, the cursor keys, which move the little person around. Breaking into an abandoned mansion to search for some missing diamonds, you'll have to poke into every nook and cranny to find them. Your interaction key is Z: it picks up items, when the prompt appears. It's also how you retrieve them from your inventory, by holding it down.

I like an adventure game with a big inventory, but I also enjoy *Spooky*'s slickly linear approach. The house is a clockwork chain of puzzle-solving: you clear the ghost with the torch, you attract the fly with the dead fish, you take the dead fish to the cat to get it out of the way. These are not hard puzzles, but they're crunchy enough to make it satisfying to gradually unlock the mansion.

A spooky atmosphere made with just a single colour.

Tom Sykes

★★★★☆

GAME CHANGER

Wolfenstein: The Old Blood

Samantha Greer's story is for all those map editors who fight boredom.

■ **Release:** May 5, 2015 **Developer:** Machine Games **Publisher:** Bethesda **Link:** bit.ly/2ynUbo4

I love Machine Games' neo-*Wolfenstein* series, a collection of winkingly self-serious shooter campaigns that play out like Inglorious Basterds by way of *Half-Life 2*. With the weather now getting a good bit colder, it seemed as good a time as any to tuck into the developer's cosy, Bavarian reimagining of *Return to Castle Wolfenstein*, spiffed up for the new continuity and titled *The Old Blood*.

I remember really loving *The Old Blood* in particular – I first played it in the lead up to the release of *The New Colossus* back in 2017, and I went in expecting a fun FPS romp spiritually connecting me to the chilly autumn nights I spent gaming in years past. I did have a good time, but two *Doom* reboot entries and a mini renaissance of indie FPSes since have spoiled me, and I found *The Old Blood*'s flaws as an FPS more grating than before.

Cloak and dagger

It starts out immediately playing to the series' strengths. With Valve no longer making videogames with any regularity, Machine Games might be the best in the biz when it comes to those first person gameplay cutscenes spearheaded by *Half-Life*. *The Old Blood* begins with one such sequence, showing BJ Blaskowicz drive up to Castle Dubbs, here a 1936 Berlin Olympics-esque concrete monstrosity emerging out of the end of a canyon. Your acerbic British spy pal Wesley gives you the lowdown: Wolfenstein's castellan, Helga von Schabbs, has intel on Nazi general Deathshead's secret base. You've got to go in, grab the docs and bring it back to the OSA (*Wolfenstein*'s cheeky off-brand OSS, the real life precursor of the CIA.)

> "With Valve no longer making videogames with any regularity, Machine Games might be the best in the biz when it comes to those first person gameplay cutscenes spearheaded by Half-Life"

In addition to being a great cinematic, this intro highlights something I really like about *The Old Blood*'s structure. It has a sense of place reminiscent of City 17 and the Citadel in *Half-Life 2*. For the entire first two thirds of the game, you're either in the guts of Castle Wolfenstein, or you can look up and see it looming over you. This intro gives you a preview of the castle, the cable cars and suspension bridge you'll use to escape it, and the town of Paderburg where you'll have an explosive, building defence shootout to close the first act. I really think that sense of honest, cohesive geography outside straight-up open world games is a bit of a lost art, and *The Old Blood*'s deployment of it is one of my favourite parts of the game.

Getting into the castle itself, I'm treated to a bit of that Tarantino undercover nail biter dialogue Machine Games is so good at. Act 1 boss Rudi Jäger stops BJ at a security checkpoint. In response to a question about his cover story home town of Frankfurt, BJ mutters in halting, C student at the beginning of their first semester German, "Jah, ein... hot dog." Jäger bursts out laughing at the obvious joke by the SS man

he's talking to, and waves BJ on his way.

Similar to how Skull Face in *Metal Gear Solid V* delivers his big-ass language parasite monologue to the completely wrong guy after working on it for like 15 years, it rules that all these Nazi guys in the Machine Games *Wolfensteins* keep giving heartfelt, sinister soliloquies to BJ, who can barely understand German.

Stealth mode

BJ and Wesley blow their cover and get caught, and after that incredible opening, things take an unfortunate turn. For all its incredible, imaginative vistas of a retro-futurist alternate Nazi history, the neo-*Wolfenstein* series loves stuffing its levels with an alarming amount of dull industrial hallways. A forced stealth sequence with restrictive pathing around The Old Blood's bullet sponge übersoldaten enemies really seals the deal on an absolute dud of a first proper level.

Things do get better after your initial prison break. Most of the series' stealth bits involve crouch walking around semi-open arenas, eliminating Nazi officers to head off reinforcements. There are multiple pathways and approaches to perfect stealth each, and if you get spotted you can just fall back on gunplay.

Takedowns and silenced pistols are nice, but I love the games' throwing weapons: knives in Order and Blood, and tomahawks in Colossus. The tomahawk has an almost laser-like precision and insanely fast travel time that I love (look at the arm on this guy! Am I playing as BJ Blaskowicz or 'Touchdown' Tom Brady?) but I quite like the lackadaisical arc The Old Blood's knives take through the air. You gotta adjust your throws accordingly, leading your targets and aiming well above where you want to hit, and it's always hilarious to see enemies instant death ragdoll from such a low-velocity projectile.

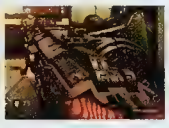
Pipe bomb

I have to make an aside here to talk about the pipe. Early in the prison level, BJ gets his first melee weapon of the game, a section of lead pipe. It can be split

PACKING HEAT

The best firearms of alternate 1946

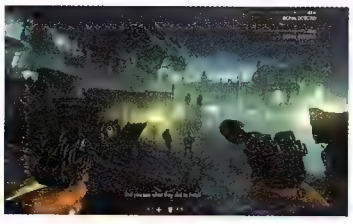
KAMPFPISTOLE
This tiny little thing looks like a flare gun, but it's actually The Old Blood's rocket launcher. I saved all my ammo for the occasional boss.

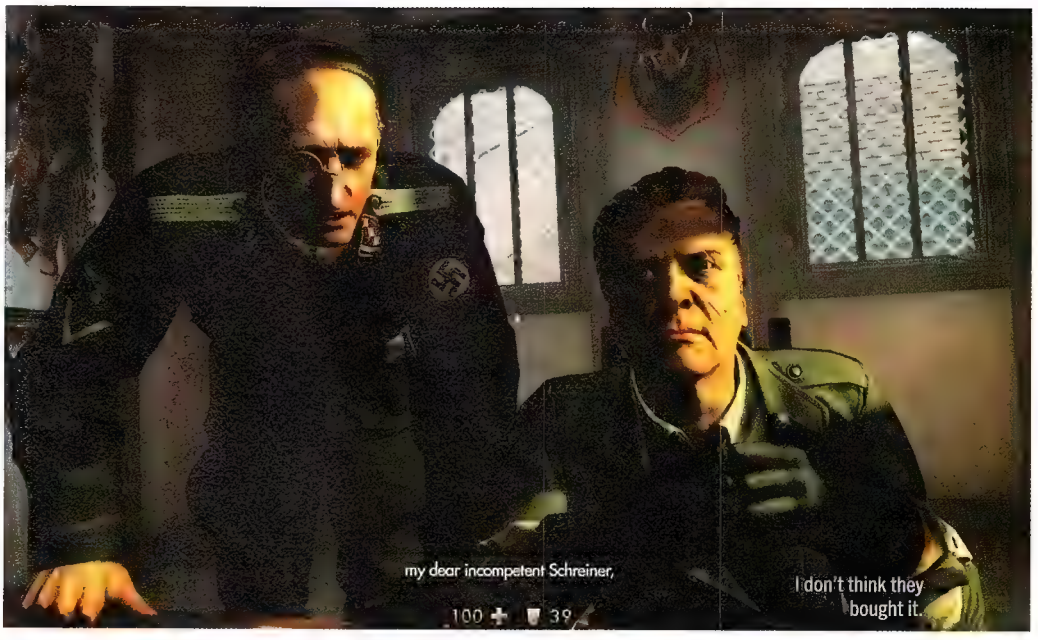


STOCKHAMMER
A retro riff on the Machine Games *Wolfensteins*' signature auto shotgun. It's at its best when dual wielded.

SAWN OFF SHOTGUN
You get this one well after the Stockhammer. It deals more damage per shot, and has more ammo pickups.

BOMBENSCHUSS
A tasteful and fun videogame sniper rifle. Ammo pickups are rare, but not so much that you can't use it pretty regularly.





Top: What secrets await in the Spooky Graveyard?

Right: This fight with a Holy Roman Empire Frankenstein kinda blew.

Left: Hard to say anything snide about that view.

in two pieces and used like dual knives, or connected together to form a big club. BJ uses it for everything in this game. Section of climbable wall? Use your pipes as climbing tools. Unaware Nazi? Perform a takedown with the pipe. Your quick melee is an attack with the pipe. You use the pipe to pry open doors. BJ's gaze will linger on the pipe like he's pondering it before using it in a cutscene. That last one sounds like a joke, but it's not.

What is going on with this pipe? It feels like someone on the publishing side wanted to produce a memetic melee weapon a la Gordon Freeman's crowbar, or else one member of the dev team was just really into pipes – I can imagine either one of those characters insistently returning to the subject at meetings until the rest of the team relented. I mean, the pipe is fine, I guess, but it really lacks the charisma and verisimilitude of *Wolfenstein*'s knives or tomahawks, and it never shows up again after *The Old Blood*. Is it unhinged of me to ponder the pipe so closely? Perhaps, but only as unhinged as the wayward pilgrim who made it such a focus of *The Old Blood* in the first place.

Quiet retort

The shooter combat when things get loud is... fine? Machine Games' 'Steins occupy a midpoint between super fast boomer shooters and stop-and-pop, Xbox 360-era fare. This isn't a bad thing – again, I'd put *Half-Life* in the same category, and *Half-Life* is perfect – but the neo-*Wolfensteins* always feel like they're a tweak or two away from a truly great FPS gunplay groove.

BJ moves just a bit too slowly, enemies blend with the environments too much and don't have adequate location feedback, and *The Old Blood* in particular is in desperate need of that *Call of Duty*-style crosshair flash and plfft plfft plfft sound effect when you score a hit on an enemy. *The Old Blood* is still fun, and has some imaginative set pieces, but its shooter fundamentals really pale in comparison to recent indies targeting a comparable design niche like *CULTIC* or *Fortune's Run*.

> "Most of the series' stealth bits involve crouch walking around semi-open arenas, eliminating Nazi officers to head off reinforcements."

The Old Blood weaves together a competent shooter campaign as it winds its way through the castle, eventually shifting to a final act in the nearby town of Wulfberg. The game ends on a bit of a sour note with a lacklustre final boss and a distinct 'let us never speak of this again' energy to its transition into *The New Order*'s opening scenes.

Annoyances aside, *The Old Blood* still managed to be a nice companion on some early fall nights. I leisurely made my way through on normal difficulty on my Steam Deck, hitting an hour or two each night before bed. There are worse ways to while away weekday autumn evenings while your girlfriend watches TikToks nearby. I just hope Machine Games tweaks its shooter mechanics up to a level matching its storytelling in time for the hopefully-still-coming-and-not-a-co-op-shooter Wolfenstein 3: The New [Insert Object or Concept]. ■

RETRO

Ravers of the lost art

Collecting retro PC games in their original big boxes is more popular than ever, but don't expect to get rich quick, and watch out for crooks. Particularly David Crookes, who reveals all here.

Commodore is a name that resonates strongly with computer users of a certain age. The company that made it famous created the Commodore 64 – still the biggest-selling single computer of all time. It also produced the PET, the VIC-20 and, of course, the Amiga range that was first introduced in 1985 and went on to achieve sales of around five million.

Given such a pedigree, you'd think a revival of the Amiga would proudly bear the Commodore branding. But when such a project was announced by Retro Games Ltd, the name was nowhere to be seen. It didn't appear in the press release; it didn't figure on the images of the packaging; and it won't take pride of place on the new machine itself.

"The Amiga has really been held back over the years by legal issues," explained Jonah Naylor, editor of *Amiga Addict* magazine. And indeed it has. Commodore folded in 1994 and its assets ended up in the hands of Escom, the German PC manufacturer that went bankrupt three years later. But understanding who owns what has been akin to wading in muddy waters ever since. "Thankfully, these legal problems are finally starting to settle," Naylor said with a sigh.

To delve too deep into exactly what has happened over the years would drown us in legalities, take up far too much space and, quite frankly, be prone to error. Suffice to say, the assets, patents and trademarks of the computers and key software are owned by different entities, much to the frustration of a hardcore group of Amiga fans who have remained loyal to the computer for more than 25 years.

Above: Never mind Game of Thrones, this is Anne Bras' throne of games.

Below: Dune opened up to reveal an open-mouthed sandworm.

"Legal battles have continued to plague the Amiga's future and block continued innovation," lamented Jamie Krueger, one of many enthusiasts determined to keep the computer alive. It's precisely why the new Amiga is called THEA500 Mini (it can't even use the Amiga name), but it seems at least to be on safe ground. "We own our own trademarks and shapes," said Retro Games managing director Paul Andrews. "So basically other third-party legal battles are none of our business."

As the name suggests, THEA500 Mini is doing two key things: replicating the look and feel of the Amiga 500 – the popular model released in 1987 – yet doing so in a case that's far smaller than the original footprint of 325 x 470 x 65mm. You only need to take a cursory glance at the console's prototype to see that it will be barely bigger than the accompanying original-style two-button mouse. But that does mean a compromise has had to be made.

Anne Bras has the world's biggest collection of big box games.

Recalling the past

The clue is in the word "console". Just like a previous product by Retro Games (THEC64 Mini, which was based on the Commodore 64), the revived Amiga won't include a working keyboard. If users want to type, they'll have to use the mouse or the bundled eight-button gamepad to control an onscreen keyboard instead. Users can connect a standard external PC keyboard to the machine, but there's no denying it's already a bugbear for some Amiga fans, who had hoped that Retro Games would go straight in with a full-size replica of the Amiga 500, just as it eventually did for its Commodore 64 spin-off when it launched THEC64.

"People ask us all the time why we make miniature consoles first," Andrews told *APC*. "Well, in very rough figures, around 80 percent of the global sales of THEC64 range were the mini version, so the perception that the public want a full-sized working machine with a keyboard is not what we're seeing. We do want to supply that 20 percent with a full-sized working machine as well, though."

But why bother bringing the Amiga back in the first place, small, large or somewhere in between? This is, after all, a machine that hasn't been around for some 25 years, so just what is it about the Amiga that keeps enthusiasts hanging on?

Krueger is clear: "One thing you need to understand is just how personally influential these machines were to countless individuals and how they changed their lives forever. Over the years, I have heard dozens of stories from people that trace their professional careers, lifetime friendships and even how they met their future spouse back to the Amiga," he said.

It also helps that, back in the day, the Commodore Amiga was leaps and bounds ahead of anything available at the time. "It was truly a powerful, elegant and user-centric machine, and it certainly wasn't yet-another-PC, soon to be tossed aside in favour of the newest rehash of the same old thing," Krueger added.

As proof, he points to how the Amiga's Motorola 680x0 CPU in combination with specialised custom chips made it a powerhouse of computing. "The custom chips offloaded many normally CPU-intensive tasks such as graphics, sound processing and other logic, freeing the CPU to execute programs," he explained.

"Its multitasking operating system was also arguably the first truly pre-emptive multitasking OS ever released for a personal computer. When Windows was a mere shell over MS-DOS and the average PC was barely able to display 16 colours and beep, the Amiga was displaying 4,096 colours, rocking four-channel stereo music and running several programs at the same time."

Updating a classic

THEA500 isn't going to reinvent the wheel. Instead, it aims to give people a flavour of why the Amiga was so popular. It emulates the original and enhanced chipsets of the Amiga 500 while supporting the Advanced Graphics Architecture of the 32-bit Amiga 1200. Many months have been spent trying to produce an instantly recognisable machine that replicates most of the original's functionality.

To do that, Retro Games struck a deal with Cloanto, which holds the rights to the original Amiga ROMs (though the internal code was created by Retro Games). It also worked hard on perfecting the look of the machine. "A lot of time was spent trying to get the CADs and the mouse just right," Andrews said. "Obviously, much of THEA500 Mini has been made smaller than the original machines, and we've had to make the mouse optical rather than a roller ball. But we've tried to make the machine look and feel right physically, just as we did with THEC64 Mini."

> "One thing you need to understand is just how personally influential these machines were to countless individuals and how they changed their lives forever."

Importantly, the company needed to ensure the new device would work well with today's technology, so there are three USB ports into which you can connect the mouse, gamepad and a flash drive (there's no working 3.5in disk drive, after all). There's also

The 11th Hour came in an elaborate clockwork box.

an HDMI port so that the machine can connect to modern TVs. It does mean THEA500 won't be compatible with many past adds-ons. "It's unlikely old hardware will work without extensive mods," Andrews said. But who knows? New third-party hardware may end up being created over time.

For now, built-in software will allow you to replicate the past by selecting multiple scaling options and a CRT filter – the latter allowing the screen to resemble an old cathode-ray tube monitor. There's also a choice between 50Hz and 60Hz screen refresh, and a lot of time has been spent on perfecting the innards; no easy task, given the original machine had dedicated chips to handle different functions as well as direct memory access.

"We've ended up with a compromise between hardware and software complexity," said Chris Smith, Retro Games' chief technology officer, who says the biggest challenge was creating a hardware platform that would provide the power needed to run games at their full frame rate without tearing at 720p while keeping costs as low as possible. The THEA500 Mini could potentially even run Workbench, the graphical file manager of AmigaOS, as well as serious software such as DPaint, which was used to create many past videogames for the computer. "If it works on emulation, then things could and should work," said Andrews. In reality, we'll have to wait and see.

We certainly know that many games will run: THEA500 comes with 25 built-in titles, including *Alien Breed 3D*, *Another World*, *Kick Off 2*, *Pinball Dreams*, *Simon the Sorcerer*, *Speedball 2: Brutal Deluxe*, *The Chaos Engine*, *Worms: The Director's Cut* and *Zool: Ninja of the Nth Dimension*.

"You will also be able to side-load third party software into THEA500 Mini if you have the legal right to do so and, from day one, we have made the Mini work with WHDload [a software package that makes it easy to install and run floppy-disk-based games]", said Andrews. This also opens THEA500 Mini to the dozens of homebrew games that are being released. "It would be great if THEA500 Mini inspired more people to code again," Andrews added.

In that sense, THEA500 Mini supports the endeavours of the hardcore Amiga fans who have long sought to attract more users to the platform. "This was the machine that launched careers and invented new industries nearly overnight," said Krueger. "It was the machine that NewTek used to revolutionise the television industry with their incredible Video Toaster; the machine that NASA engineers chose to build rocket telemetry tracking hardware around."

To that end, Krueger reckons THEA500 Mini is a "very nice addition to the Amiga world", and it's a sentiment shared by Naylor. "THEA500 will be a showcase for the Amiga as a fantastic gaming machine and it's a nod to a classic computer that many of us started out on," he told *APC*. "It will also be nice to have an Amiga product available at major retailers again for the first time in years. There are already new and more advanced Amigas available, but these can be expensive and complex to get into."

Risky endeavours

Those more advanced machines have been created by enthusiasts. "The community has kept the Amiga alive and thriving," Naylor said. "You only have to look at vital software and hardware releases such as the game hard drive installer WHDLoad, Gotek and OpenFlops floppy emulators, the Compact Flash IDE interfaces and all the many and sundry accelerators to know the Amiga community can achieve anything it wants to, if it puts its mind to it. There's a surprise around the corner every week."

One of the biggest developments over the years has been the creation of a "Next Generation" line-up of Amiga machines. These have far surpassed the capabilities of the original Commodore line-up – the one that THEA500 Mini emulates and which the Amiga community calls Classic.

Next Generation describes the

The Big Box PC Game Collectors group on Facebook has 6,500 members.

Collectors are reviving the lost art of big box PC games.

higher-powered PowerPC-based machines that have since been made by enthusiasts, including the AmigaOne X5000 developed by A-EON Technology. "The custom chips are gone and replaced with the same PCI-E expansion bus, RAM, storage controllers, USB interfaces, video and audio hardware as can be found in the PC," Krueger said. "The main CPU is the RISC-based PowerPC instead of the more common CISC-based X86 architecture, but performance is comparable."

Krueger says the Next Generation Amiga machines share the original Amiga operating system at their core. "The Next Generation machines run PowerPC-based AmigaOS 4.x, while the Classic machines run 68K-based AmigaOS 3.x," he said. What's more, both AmigaOS4 and AmigaOS3 are still in development.

Krueger spends time porting the AmigaOS to modern hardware while continuing to develop it for the Classic line. "The primary accomplishment of the AmigaOne X5000 has been to provide a truly fast way to run AmigaOS with modern resolutions on a dedicated system rather than emulation." In that sense, it's a world apart from THEA500 Mini, so will he still buy one of Retro Games' machines?

"In general, I am in favour of anything that brings new awareness to the Amiga computers," he said, before sharing that he already has his own plans for it, albeit perhaps not quite what Andrews and his team had intended. "Personally, I will take THEA500 Mini apart, build it into a full-size A500 case and make use of a full original A500 keyboard adapted to USB. I want to see how far I can push the emulation system."

But then this will be the ongoing attraction to many Amiga users: to see just what mods and hacks they can perform on THEA500 Mini. By pushing at the boundaries of the technology they have at their disposal, they'll merely be continuing the trend that started all those years ago when Commodore was a force to be reckoned with.

"The Amiga was years ahead of any other home computer when it was released in 1985," said Naylor. "In fact, the original was so groundbreaking that it hardly changed in the next ten years – it took that long for the competition to catch up. The community loves the Amiga because it is more than just a great games machine, and could wipe the floor with the PC and Mac in its day. But more than that, the Amiga doesn't just feel like a tool to achieve your goals. Its whole ethos is one of innovation and community."

So to the big question: how much and where to buy? You can order THEA500 Mini from Amazon for $199, and the official sirte is at **retrogames.biz/products/thea500-mini/** and it's packed with info and a very good FAQ. ■

Benjamin Wimmer in front of his large collection of big box games.

CHIP CHAT

JOEL BURGESS REPORTS ON THE UNUSUAL SIDE OF TECH NEWS

© palmerluckey.com

PALMER LUCKEY BOASTS HE MADE A VR HEADSET THAT KILLS YOU IF YOU DIE IN-GAME

New defence golden boy gets thirsty on lethal tech.

Sure there's no shortage of sci-fi stories about virtual reality with deadly consequences, but for the most part it's generally discussed in order to highlight how bad and dystopic it could be. Clearly the Oculus founder, Palmer Luckey missed this memo, bragging in a blog post in November that he had built "the first non-fiction example of a device that can actually kill the user." The headset apparently has explosive charges connected to a narrow-band photosensor that detonates when the screens flash red at a specific frequency. Having not put it on yet, Luckey likes to consider it as: "just a piece of office art, a thought-provoking reminder of unexplored avenues in game design."

IKEA THREATENS TO SUE INDIE HORROR SURVIVAL GAME SET IN A FURNITURE STORE

Legal reps. demand dev change game to make it look less like the game is set in an Ikea.

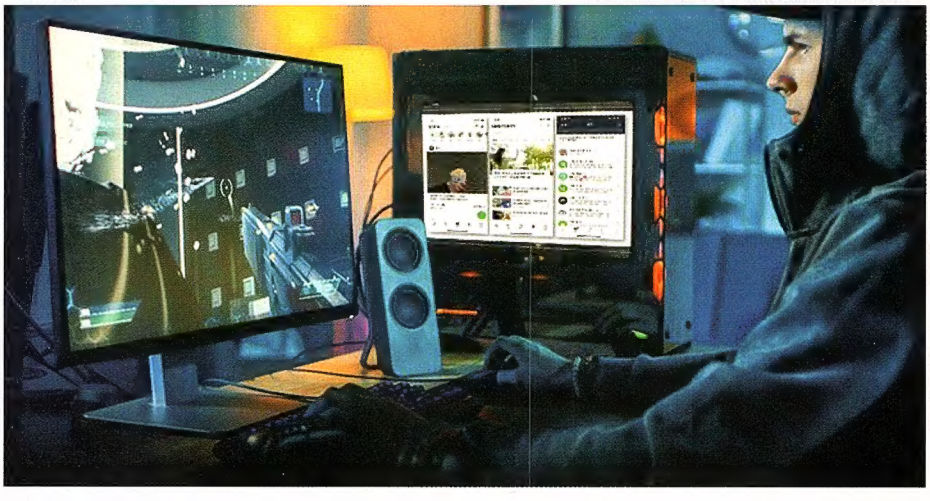
Jacob Shaw, an independent developer behind the successful Kickstarter game, *The Store is Closed: Infinite Furniture Store Survival Game*, is being threatened with legal proceedings by Ikea's New York legal representatives. The company argued that Shaw's use of a blue building with a Swedish name in yellow font for the furniture store the game is set in, is too close to Ikea's copyrighted branding and demanded that he change it. While Shaw told Kotaku that a lot of effort went into ensuring Ikea was never mentioned, the dev simply doesn't have the resources to stand up to Ikea's demands... whatever they are.

CHIP CHAT

Asrock Case display

Turn your tower into an AIO with this Asrock MB attached case display.

What's better than a PC case adorned with more RGB lights than an overachevier's house on Christmas eve? A PC case with enough RGB pixels to make a display, according to Asrock. The PC motherboard manufacturer Asrock has touted a new 13.3-inch Side Panel Kit that is compatible with some of its motherboards. The full-HD display is designed to sit on the inside of the glass panel that you usually use to see the RAM modules that cost you twice as much as the non-RGB variants and can be set up to display useful hardware stats or do other critical things like play *Age of Empires 2: Definitive Edition*.



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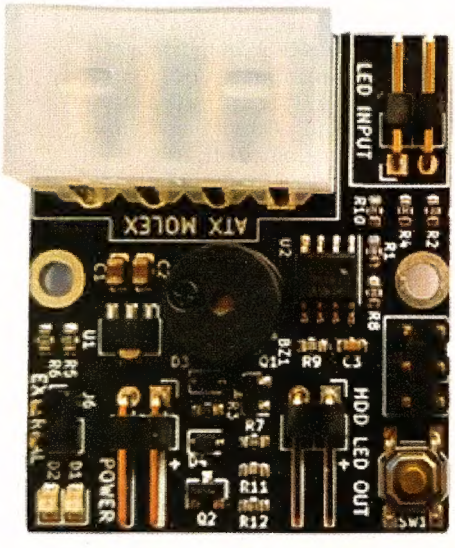
HDD CLICKER V0.2

Get all the nostalgia of a HDD without the lag.

For kids growing up with today's virtually silent consoles and PCs it'll be hard to fathom the sound of a mechanical hard drive sucking the last remnants of a digital thickshake through a straw, but prior to the solid state hard drive there was no option but to enjoy the lengthy ritual of the HDD-cricket-blender as it diced and delivered the ones and zeros of your computer's OS like a speedy robot teppanyaki chef. For anyone who's overindulged in the 'Member Berries or those whippersnappers thinkin' it'd be a laugh to make their computer sound like the PC equivalent of a Feature Phone. You can buy the HDD Clicker daughterboard from **www.serdashop.com/HDDClicker** for € 25.



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